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Information About Old Growth for Selected Forest Type Groups in the Eastern United States

Lucy E. Tyrrell, Gregory J. Nowacki, Thomas R. Crow, David S. Buckley,
Elizabeth A. Nauertz, Jeffrey N. Niese, Jeanette L. Rollinger, and John C. Zasada

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Metric-English Conversions

linear
1 m = 3.28 ft
1 ft = .3048 m

basal area
1 m^2 = 10.76 ft^2
1 m^2/ha = 26.57 ft^2/acre
1 ft^2/acre = .2296 m^2/ha

volume
1 m^3 = 35.29 ft^3
1 m^3/ha = 87.13 ft^3/acre
1 ft^3/acre = .0114 m^3/ha

area
1 hectare = 2.47 acre
1 acre = .405 ha

Cover artwork is by Lucy Tyrrell and depicts Tionesta Scenic and Research Natural Areas.

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OVERVIEW

The USDA Forest Service National Old-Growth Task Group directed each Region to develop old-growth definitions for common forest types. This publication fulfills this obligation for the Eastern Region by compiling information about old growth for nine forest type groups that occur in the eastern United States.

Old growth can be defined conceptually or operationally. There are a number of "definitions" for old growth in the East, but no consensus on the concept. Old, uneven-aged forests, with large trees and lots of dead wood, located on productive sites at low elevations that have not experienced large-scale natural or human disturbance, embody the quintessential old-growth concept. However, the boundaries of the concept of old growth are flexible depending on what factors are important to those considering the issue, including forest types involved, site factors, management objectives, and values associated with old growth. Old-growth forests are relatively old and relatively undisturbed (Hunter 1989). Old growth is difficult to define because of (1) lack of consensus as to which forest types occur in an old-growth condition, (2) difficulty in choosing which attributes to use, (3) the variation that exists in species stature and spacing due to site conditions and elevation, (4) lack of available data, (5) questionable representativeness of remnant old-growth examples, (6) changes in forest structure due to altered disturbance regimes since European settlement, (7) influences of pollution and exotics, and (8) the need to move beyond stand-level treatment of old growth.

Stand age and the lack of human and natural catastrophic disturbance can be used as selection criteria for allocating old growth. To maintain or develop examples of old growth as reference ecosystems, old growth should be allocated for all forest types, especially those comprised of long-lived species, within all ecological units of the National Hierarchy (Keys *et al.* 1995). To best provide for old-growth function in the landscape, stand shape and size, connectivity to other old-growth areas, allowances for potential natural disturbance, and co-planning with other protected areas should be considered.

Compiled here is information for nine forest type groups that occur in the USDA Forest Service Eastern Region. Forest type groups included in this publication are: beech-maple-basswood, northern hardwood, dry and xeric oak, mesic and wet-mesic northern oak, hardwood wetland (all hardwood dominated), conifer-northern hardwood (mixed forests), and northern pine, montane and allied spruce-fir, and subboreal spruce-fir (conifer-dominated).

Information from studies relevant to each forest type group is included in this publication regardless of where the study sites were located (*i.e.*, sometimes beyond national forest lands). From a review of hundreds of references, a total of 292 references contained some relevant data about tree- and stand-level attributes for the nine forest type groups.

A background narrative section for each forest type group includes information about species composition, geographical extent (physiographic provinces, ecological units), soils, disturbance, and relation to other forest type groups. Selected examples of old-growth stands are also listed.

Maps for each forest type group show the location of study sites from which the attribute data were obtained. Within the tables for each forest type group, information is arranged alphabetically by reference for ease of reviewing data. Tables contain information on location, size, and elevation of study sites; criteria for stand selection; stand composition; sampling methods; tree density; tree basal area; average and maximum tree age by species; maximum tree diameter by species; average canopy height; percentage of canopy in gaps; density, basal area, and volume of snags; and density and volume of logs.

The information presented in this publication does not constitute minimum standards or operational definitions for distinguishing mature forests from old growth. Rather, a range of values for each old-growth attribute for each forest type group is summarized regionally from published and unpublished sources. National forests can use this information in planning and managing for old growth.

Blanks in tables (lack of available information) indicate opportunities where additional research is needed to understand more fully the nature of old growth.

INTRODUCTION

Outer Island, *Apostle Islands National Lakeshore, Wisconsin. Many of the characteristics commonly associated with old-growth forests can be observed in the hemlock-hardwood old-growth area at the north end of Outer Island, Apostle Islands, Wisconsin. These characteristics include big trees (the diameter of the hemlock being measured is 89.5 cm), patches of different tree ages due to natural disturbance, and no evidence of logging. See Tyrrell and Crow (1994). Photo 7/90 by Sue Lietz.*

OBJECTIVES OF THIS PUBLICATION

The objectives of this publication are to:

(1) Review and clarify the concept of old growth in the eastern United States.

(2) Compile available information about tree- and stand-level old-growth structural attributes for selected forest type groups occurring in the USDA Forest Service Eastern Region.

(3) Provide regionwide information about old growth (a range of values for structural attributes) for national forests to use in planning and managing for old growth.

(4) Assess where information about old growth is lacking to help guide future research efforts.

LIMITATIONS OF THIS PUBLICATION

This publication does NOT:

(1) set Forest Service policy about old growth...

...but the information CAN be used by national and other public forests engaged in policy issues that raise such questions as:

How should forestwide planning include provision for old growth?

How should allocations for old growth relate to ecological units?

What forest types need active management to restore or maintain old-growth features and which do not?

What are appropriate management goals for areas allocated to old growth?

(2) establish minimum criteria or provide operational definitions that distinguish old growth from mature forests...

...but comprehensive information is summarized for each forest type group, from the published literature and unpublished sources, as a range of values for old-growth structural attributes (*e.g.*, stand density, maximum tree diameter). The data about stand structure presented in the tables must be interpreted in light of the species composition, geographical location, soils, elevation, and disturbance history of the site from which the data were collected. No regional definition is possible given the wide natural range of variation in old-growth conditions due to these site differences.

(3) define old growth using structural attributes...

...but sufficient resources are provided to help determine whether such definitions would be useful, feasible, practical, realistic, or even necessary, or how much they would vary.

(4) provide data specific to a particular national forest, geographic region, ecological unit, elevation, soil type, or species composition...

...but, because complete information is provided for each study contributing data about old growth, through careful interpretation one can screen all the data for those that are relevant to one's own forest setting based on its composition, location, soils, elevation, and disturbance history.

HISTORICAL BACKGROUND OF OLD-GROWTH "DEFINITIONS"

National Forest Service Direction

For more than a decade the USDA Forest Service has been involved with the issue of old growth and the development of old-growth definitions, initially in the Pacific Northwest (*e.g.*, Franklin *et al.* 1981, Old-Growth Definition Task Group 1986). Intermittently from January 1989 to January 1992, the Forest Service convened a National Old-Growth Task Group to consider the issue of old growth. As a result, a position statement on National Forest Old-Growth Values was developed and issued by the Chief on October 11, 1989, along with a national Generic Definition and Description of Old-Growth Forests. This generic definition established a framework for defining old growth in all regions. The definition states that "old-growth forests are ecosystems distinguished by old trees and related structural attributes...encompassing the later stages of stand development" (USDA Forest Service 1989).

The Forest Service set out to develop definitions for old-growth forests partly because the National Forest Management Act of 1976 mandated that the agency provide adequate habitat for threatened or endangered wildlife species. Because structural attributes of old growth provide many of the habitat features that these wildlife species require, structural attributes featured prominently in definitions and discussions about old-growth criteria. The Forest Service also wanted to know how much old growth there is at present (inventory) and which areas being considered for the development of future old growth (land allocation) have the most old-growth structural characteristics already.

Based on these needs (wildlife habitat, inventory, and land allocation), the Forest Service generated a list of attributes to be used for distinguishing old growth. The following list (USDA Forest Service 1989) was intended to be used by each Forest Service region to establish definitions for specific forest types: (1) large trees for species and site, (2) wide variation in tree size and spacing, (3) accumulation of large, dead trees (snags, logs), (4) tree decadence, and (5) tree canopy structure (layers, gaps). Old-growth definitions were first produced in the western regions of the Forest Service (*e.g.*, Pacific Northwest and California Regions (Old-Growth Definition Task Group 1986), and Alaska Region (Ecology Steering Committee 1992a, 1992b)).

Eastern and Southern Region Joint Effort with The Nature Conservancy

Given the national direction for developing regional definitions of old growth for common forest types, and because the Eastern and Southern Regions of the Forest Service share many forest community types, in 1990 these regions began a joint effort to address the old-growth issue. Representatives from the Forest Service's Southern and Eastern Regions, along with the Southern, Southeastern, North Central, and Northeastern Research Stations met in Muddy, Illinois in May 1991, to discuss how to develop "definitions" for forest types occurring in the eastern United States (see Appendix A). The Southern Region contracted with The Nature Conservancy to provide a preliminary list of forest type groups and narrative descriptions for them, to conduct a literature search (see Nowacki and Trianoski 1993), and to compile a list of old-growth stands that are representative of each forest type group. These portions of the project were carried out primarily by Greg Nowacki during his tenure with the Southeastern Regional Office of The Nature Conservancy.

The combined team of the Eastern Region and North Central and Northeastern Stations agreed to compile information for 15 forest type groups (Table 1) in one publication (represented here). During 1992, this group funded Lucy Tyrrell in a year-long post-doctoral position at North Central in Rhinelander, Wisconsin. Time was spent studying the concept of old growth in the East through site visits and discussions, assembling publications and other references to review, and compiling information about these forest type groups in an old-growth condition.

To complete the project, in 1995 additional help in reviewing literature and other references was obtained from North Central scientists and technicians. Lucy Tyrrell coordinated these final efforts. On reevaluation of the 15 forest type groups, three of them were dropped because they do not occur, or occur only on a few acres, on national forests in the Eastern Region (Great Plains Riparian Hardwoods, Atlantic White-Cedar, and Hardwood Freshwater Tidal Swamps). Time and funding limitations prevented compiling information on three forest type groups and part of a fourth (Rocky Thin-Soiled Cedars, Aspen-Birch, and Northern Conifer Wetlands, and Northern Pines—pitch pine).

Scientists in the Southeastern and Southern Stations agreed to summarize old growth for 20 forest type groups, nine of which co-occur in the Eastern and Southern Regions (Table 1). The forest type groups common to both regions are: coastal plain upland mesic hardwood forests, river floodplain hardwood forests, mixed and western mesophytic forests, dry-mesic oak forests, seasonally wet oak-hardwood woodlands (Kennedy and Nowacki 1997), dry and dry-mesic oak-pine forests, eastern riverfront forests (Meadows and Nowacki 1996), cypress-tupelo forests, and xeric pine and pine-oak forests and woodlands (Murphy and Nowacki 1997). Forest type groups occurring exclusively in the Southern Region are listed in Appendix A.

Table 1.—*List of Society of American Foresters (SAF) forest cover types (left column) (Eyre 1980) and Combined Data Systems (CDS) forest cover types (right column) (USDA 1974) that correspond to the forest type groups, as used in this publication, found within the Eastern Region of the USDA Forest Service. Not all SAF forest cover types listed for a group occur in the Eastern Region. Forest type groups are arranged by categories: hardwoods, mixed forests (conifers and hardwoods), and conifers. Forest type groups are listed alphabetically within each category.* ***Forest type groups included in this publication are in boldface type.*** *The Southern Region of the Forest Service was responsible for the forest type groups indicated by an asterisk.*

Forest type group	
SAF FOREST COVER TYPES	**CDS FOREST COVER TYPES**
HARDWOODS	
Aspen-birch (forest and woodland)	
a) successional aspen-birch forests and woodlands (interior Eastern Deciduous Forest)	
16 - aspen	91 - quaking aspen
18 - paper birch	92 - paper birch
19 - gray birch-red maple	93 - bigtooth aspen
	94 - balsam poplar
	95 - aspen-white spruce-balsam fir
b) aspen parkland forests, woodlands, and scrub (western border of Eastern Deciduous Forest)#	
16 - aspen	91 - quaking aspen
	93 - bigtooth aspen
	94 - balsam poplar
Beech-maple-basswood (forest)	
26 - sugar maple-basswood	**82 - sugar maple/basswood**
27 - sugar maple	**85 - sugar maple**
60 - beech-sugar maple	**86 - beech**
Hardwood, coastal plain upland mesic (forest) *	
53 - white oak	54 - white oak
82 - loblolly pine-hardwood	
89 - live oak	
Hardwood, northern (forest)	
25 - sugar maple-beech-yellow birch	**81 - sugar maple/beech/yellow birch**
27 - sugar maple	**85 - sugar maple**
28 - black cherry-maple	**87 - sugar maple/beech/yellow birch/red spruce**
60 - beech-sugar maple	**89 - mixed hardwoods**
Hardwood, river floodplain (forest) *	
65 - pin oak-sweetgum	58 - sweetgum/yellow-poplar
82 - loblolly pine-hardwood	61 - swamp chestnut/cherrybark/pin oak
87 - sweetgum-yellow-poplar	62 - sweetgum/Nuttall's oak/willow oak
88 - willow oak-water oak-diamondleaf oak	76 - red maple (wet site)
91 - swamp chestnut oak-cherrybark oak	79 - mixed lowland hardwoods
92 - sweetgum-willow oak	
93 - sugarberry-American elm-green ash	
94 - sycamore-sweetgum-American elm	
96 - overcup oak-water hickory	
108 - red maple	

(Table 1 continued on next page)

(Table 1 continued)

Forest type group

SAF FOREST COVER TYPES	CDS FOREST COVER TYPES
Mesophytic, mixed and western (forest) *	
a. mixed mesophytic	
25 - sugar maple-beech-yellow birch	56 - yellow-poplar/white oak/northern red oak
27 - sugar maple	81 - sugar maple/beech/yellow birch
57 - yellow-poplar	83 - black cherry/white ash/yellow-poplar
58 - yellow-poplar-eastern hemlock	85 - sugar maple
59 - yellow-poplar-white oak-northern red oak	
60 - beech-sugar maple	
b. western mesophytic	
52 - white oak-black oak-northern red oak	56 - yellow-poplar/white oak/northern red oak
59 - yellow-poplar-white oak-northern red oak	
Oak, dry-mesic (forest) *	
44 - chestnut oak	52 - chestnut oak
52 - white oak-black oak-northern red oak	54 - white oak
53 - white oak	55 - northern red oak
55 - northern red oak	56 - yellow-poplar/white oak/northern red oak
110 - black oak	59 - mixed oaks
	84 - red maple (dry site)
Oak, dry and xeric oak (forest, woodland, and savanna)	
a. northern subgroup	
14 - northern pin oak	
42 - bur oak	
110 - black oak	
b. widespread subgroup	
40 - post oak-blackjack oak	**52 - chestnut oak**
42 - bur oak	**57 - scarlet oak**
43 - bear oak	**59 - mixed oaks**
44 - chestnut oak	
110 - black oak	
c. southern subgroup	
67 - Mohrs (“shin”) oak	
72 - southern scrub oak	
89 - live oak	

(Table 1 continued on next page)

(Table 1 continued)

Forest type group

SAF FOREST COVER TYPES	CDS FOREST COVER TYPES
Oak, mesic and wet-mesic northern (forest, woodland, and savanna)	
42 - bur oak	**53 - black oak/scarlet oak/hickory**
52 - white oak-black oak-northern red oak	**54 - white oak**
53 - white oak	**55 - northern red oak**
55 - northern red oak	**59 - mixed oaks**
110 - black oak	**89 - mixed hardwoods**
Oak-hardwood, seasonally wet (woodland) *	
40 - post oak-blackjack oak (on heavier, clayey soils the type tends towards the post oak variant)	49 - red pine/oak 59 - mixed oaks
53 - white oak (occasionally it occurs on poorly drained bottomland soils with a high clay content)	
65 - pin oak-sweetgum	
88 - willow oak-water oak-diamondleaf (laurel) oak (the type may also occur on terrace flats and poorly drained flatwoods sites; 'oak glades' or 'pin oak flats')	
Riverfront, eastern (forest) *	
61 - river birch-sycamore	72 - river birch/sycamore
62 - silver maple-American elm	73 - cottonwood
63 - cottonwood	75 - sycamore/pecan/American elm
89 - live oak	77 - green ash
94 - sycamore-sweetgum-American elm	78 - black walnut
95 - black willow	79 - mixed lowland hardwoods
Wetland, hardwood (forest)	
39 - black ash-American elm-red maple	**71 - black ash/American elm/red maple**
65 - pin oak-sweetgum	**76 - red maple (wet site)**
108 - red maple	**79 - mixed lowland hardwoods**

(Table 1 continued on next page)

(Table 1 continued)

Forest type group **SAF FOREST COVER TYPES**	**CDS FOREST COVER TYPES**
MIXED (CONIFERS AND HARDWOODS)	
Conifer-northern hardwood (forest)	
a. hemlock as dominant conifer	
22 - white pine-hemlock	**4 - white pine/hemlock**
23 - eastern hemlock	**5 - hemlock**
24 - hemlock-yellow birch	**9 - conifers**
b. white pine as dominant conifer	
20 - white pine-northern red oak-red maple	**4 - white pine/hemlock**
21 - eastern white pine	**9 - conifers**
22 - white pine-hemlock	**41 - white pine/northern red oak/white ash**
c. red spruce as dominant conifer	
30 - red spruce-yellow birch	**9 - conifers**
31 - red spruce-sugar maple-beech	**87 - sugar maple/beech/yellow birch/red spruce**
35 - paper birch-red spruce-balsam fir	
Cypress-tupelo (forest) *	
100 - pondcypress	67 - baldcypress/water tupelo
101 - baldcypress	
102 - baldcypress-tupelo	
103 - water tupelo-swamp tupelo	
Oak-pine, dry and dry-mesic (forest) *	
51 - white pine-chestnut oak	32 - shortleaf pine
75 - shortleaf pine	33 - Virginia pine
76 - shortleaf pine-oak	38 - pitch pine
78 - Virginia pine-oak	44 - shortleaf pine/oak
79 - Virginia pine	
80 - loblolly pine-shortleaf pine	
82 - loblolly pine-hardwood	
81 - loblolly pine	
Pine, xeric, and pine-oak (forest and woodland) *	
45 - pitch pine	32 - shortleaf pine
51 - white pine-chestnut oak	33 - Virginia pine
75 - shortleaf pine	38 - pitch pine
76 - shortleaf pine-oak	44 - shortleaf pine/oak
78 - Virginia pine-oak	48 - Jack pine/oak
79 - Virginia pine	

(Table 1 continued on next page)

(Table 1 continued)

Forest type group	
SAF FOREST COVER TYPES	**CDS FOREST COVER TYPES**
	CONIFERS
Cedar, rocky, thin-soiled (woodland)	
37 - northern white-cedar (limestone cliff faces)	14 - northern white-cedar
46 - eastern redcedar (glades; granitic flatrock borders)	35 - eastern redcedar
	42 - eastern redcedar/hardwood
Pine, northern (forest)	
a) Short-lived pines, more frequent stand-inititating disturbance	
1 - jack pine	**1 - jack pine**
45 - pitch pine	38 - pitch pine
	48 - jack pine/oak
b) Long-lived pines, less frequent stand-initiating disturbance	
15 - red pine	**2 - red pine**
21 - eastern white pine	**3 - white pine**
	9 - conifers
	49 - red pine/oak
Spruce-fir, montane and allied (forest)	
5 - balsam fir	**13 - red spruce/balsam fir**
30 - red spruce-yellow birch	
32 - red spruce	
33 - red spruce-balsam fir	
34 - red spruce-Fraser fir	
35 - paper birch-red spruce-balsam fir	
Spruce-fir, subboreal (forest)	
5 - balsam fir	**11 - balsam fir/aspen/paper birch**
12 - black spruce (subtypes a, b, c)	**12 - black spruce**
107 - white spruce	**17 - upland black spruce**
Wetland, northern conifer (forest, bog)	
a. cedar swamp	
37 - northern white-cedar	14 - northern white-cedar
b. spruce-tamarack swamp and bog forest	
12 - black spruce (subtypes d, e, f)	12 - black spruce
13 - black spruce-tamarack	15 - tamarack
38 - tamarack	

Old Growth and Forest Plan Revisions

Old-growth issues are important in the Eastern Region, especially as national forest land management plans (Forest Plans) are reviewed and revised. Current Forest Plans contain various old-growth definitions and some provision for old-growth allocations (Tyrrell 1996). However, more recent efforts to plan on larger spatial scales, further incorporate principles of conservation biology and landscape ecology, and relate old growth to ecological units of the National Hierarchy (Keys *et al.* 1995) are not yet fully integrated into plans (Tyrrell 1996). Compiled information about old growth can be useful during and beyond plan revisions.

It should be noted that the information included in the tables is taken from studies with a wide range of objectives, conducted in forests and woodlands associated with many different soil types, elevations, and locations both in and beyond national forest lands. These data are the best information available at present on the nature of old growth. However, the summary tables do not represent minimum standards for distinguishing old growth from younger stands, although the information provides useful background information for developing "definitions" if they are needed. Any old-growth definition developed for "operational" purposes would have to be custom-made for the area, considering species composition, site conditions, historical disturbance, and management objectives.

WHY IS OLD GROWTH DIFFICULT TO DEFINE?

What Do We Mean by "Defining" Old Growth?

What is meant by "defining" old growth is not always clear. On the one hand, defining old growth can mean establishing what the theoretical, ecological concept of old growth is, such as referring to a stage of forest stand development. Another kind of old-growth definition sets identification criteria based on developmental or structural attributes (*e.g.*, minimum age, number of snags) suitable for classifying an individual forest stand as growth or not. There are a range of definitions, some more concept-oriented, some more operational or practical, and some with both elements (see also Hunter 1989, Duchesne 1994).

The definition that Jerry Franklin and his colleagues developed in the Pacific Northwest, which states that old-growth forests are "forest ecosystems that have developed over a long period essentially free of catastrophic (including human) disturbance...", is a conceptual definition (Franklin *et al.* 1981). However, accompanying this conceptual definition were specific identification criteria called interim standards for Douglas-fir on western hemlock sites. These standards included specific information on density and age of live trees, and specific minimum standards for snag and log quantities (Old-Growth Definitions Task Group 1986).

Eastern Versus Western Old Growth

Old-growth definitions tend to be influenced by concepts of old-growth in the West, specifically Douglas-fir forests in the Pacific Northwest. Typically, with this western bias, old growth connotes big, ancient trees, large amounts of coarse woody debris or dead wood, and no disturbance. Rather than transferring western ideas to the East, scaled down in some subjective fashion, eastern concepts of old growth should reflect the size and longevity of eastern species and the successional pathways, disturbance regimes, and perhaps even the extent of past human disturbance.

Definitions But No Consensus

There are a number of "definitions" for old growth in the East (*e.g.*, Barnes (1989) for the northern Lake States; Frelich (1986) for hemlock-hardwoods; Hunter (1989); Leopold *et al.* (1988) for the Adirondacks; Leverett (1991) for the Northeast; Maine Critical Areas Program (1983b) for Maine; Minnesota Department of Natural Resources (1994) and Rusterholz (1989) for Minnesota; Parker (1989) for mesic deciduous forests; and Whitney (1987) for temperate mesic forests). However, there is no consensus on the concept of old growth, as illustrated by how differently old growth is defined in the above examples. Tyrrell (1996) reports how definitions of old growth differ among current land management plans for national forests in the USDA Forest Service Eastern Region.

The existing definitions for eastern old growth also include both broad, conceptual ones and practical ones that give specific criteria for one or more attributes. Two examples of old-growth definitions that are broad and conceptual are Hunter's (1989) description of old-growth forests as being relatively old and relatively undisturbed by humans and Barnes' (1989) definition as a forest ecosystem dominated by old trees. In contrast, Frelich (1986) presents a specific definition for hemlock-hardwood old growth—at least 50 percent of crown area in trees >46.0 cm in diameter. Parker's (1989) definition of old growth for Central Hardwoods is also specific: having overstory canopy trees older than 150 years with little or no human-caused disturbance in the understory during the past 80 to 100 years.

What Are the Limits to the Concept of Old Growth?

Most people have some concept of old growth. Depending on the backgrounds and values of the people involved, there are differences in what the concept of old growth encompasses. However, there are some attributes of old growth mentioned repeatedly in response to the question: What is old growth? In addition, there are some forest types that, when in an old or advanced successional state, are perceived to be more bonafide examples of old growth than other forest types. Thus, even though there is no consensus on what old growth is or should be, there seem to be some fundamental or "core" notions as to what constitutes old growth in the East.

As one moves beyond the core concept of old growth, it is more difficult to gather consensus about the nature of old growth. The boundaries of the conceptual notion of old growth seem to be flexible in different ways depending on what factors are important to those considering the issue. Some factors that influence a concept of old growth include geographic location (*e.g.*, East versus West), land use history, forest types involved, management objectives, and values associated with old growth.

Modelling the concept of old growth

To model the variations in the concept of old growth that exist under different circumstances and for different forest types, and therefore to better grasp what the limits to a core concept of old growth are, the concept of old growth can be visualized as a "wheel" composed of a central hub and radiating spokes (Fig. 1). Each spoke represents a factor or attribute that may be considered in describing the concept of old growth. Not all attributes are included in all definitions of old growth, and different attributes are usually emphasized for different reasons. The hub represents an approximation of the core concept of old growth, *i.e.*, the forest condition with most "old-growthness" (sensu Spies and Franklin 1988) is near the center of the wheel. Thus an old, uneven-aged forest with large trees and lots of dead wood, located on productive sites at low elevations, connected to other old-growth sites via forested corridors, and not likely to experience large-scale disturbance, embodies the quintessential old-growth concept.

Limits of the old-growth concept (as a general concept) or the concept of old growth for a particular forest type can be plotted by assigning each attribute to a position on the respective spoke or axis. Plotting a mark along the axis can be objective (plotting known tree age of 300 years along the SPECIES LONGEVITY axis) or rather subjective (how young does a stand have to be in order not to measure up to some standard of old growth on the TREE AGE axis?). Connecting the marks on each spoke produces a polygon that can be shaded to emphasize its size. In general, the smaller the polygon, the more closely the concept of old growth resembles the core concept of old growth.

As an example, a polygon could be drawn to model the concept of old growth for the Douglas-fir forest type in the Pacific Northwest (Fig. 2A). The polygon is small, diverging from the central hub (core concept) only in terms of the successional status of Douglas-fir as a seral type. For eastern forests, the polygon for old-growth northern hardwoods (Fig. 2B) is smaller than one for aspen (Fig. 2C). Aspen diverges from our central core concept of old growth on several axes (thus a larger polygon). What kind of polygon would montane spruce-fir have?

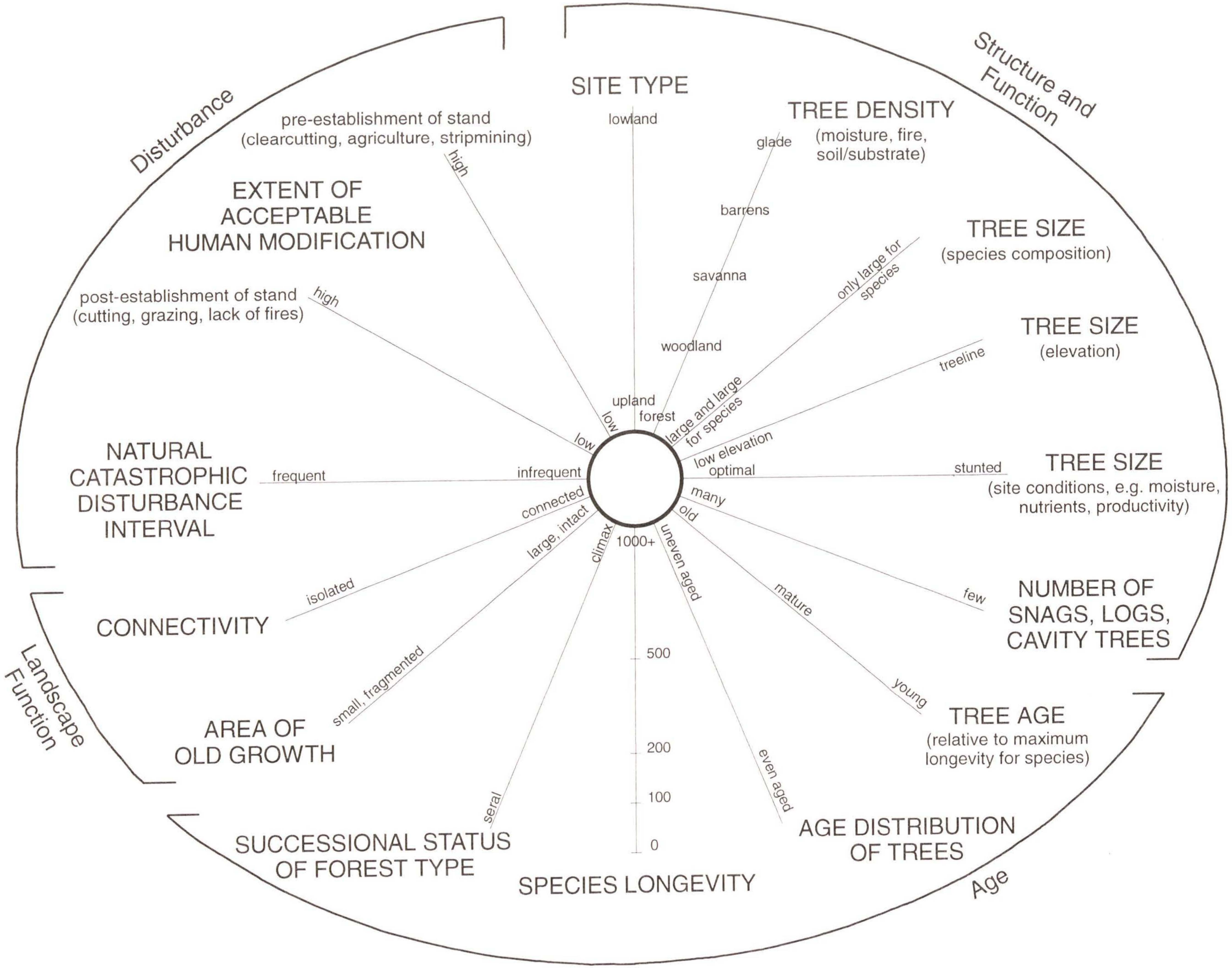
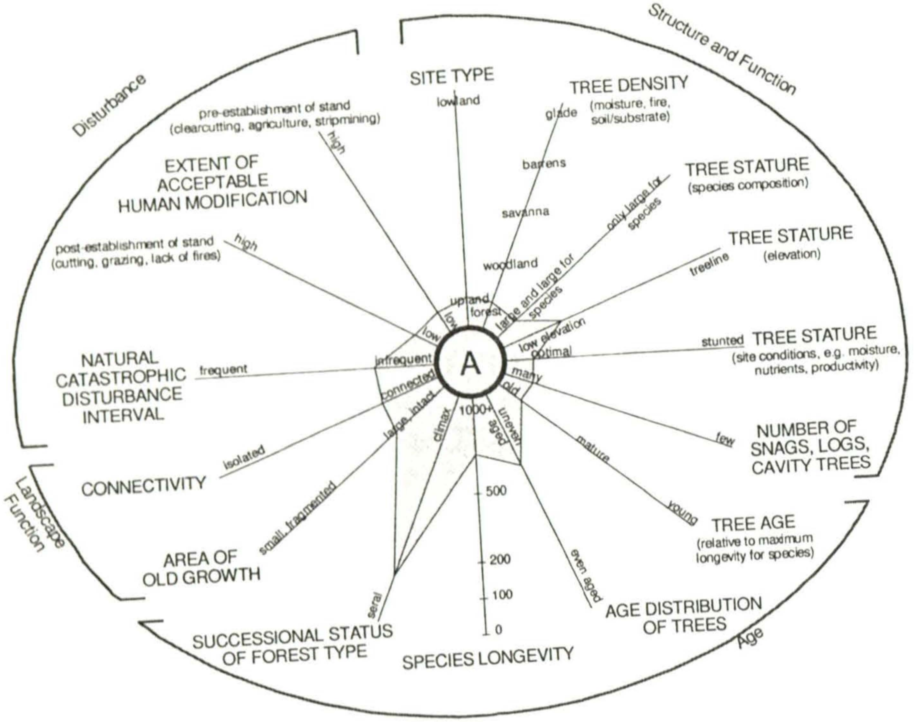

Disturbance
Structure and Function
Landscape Function
Age
SITE TYPE
lowland
upland forest
TREE DENSITY
(moisture, fire, soil/substrate)
glade
barrens
savanna
woodland
TREE SIZE
(species composition)
only large for species
large and large for species
TREE SIZE
(elevation)
treeline
low elevation
TREE SIZE
(site conditions, e.g. moisture, nutrients, productivity)
stunted
optimal
NUMBER OF SNAGS, LOGS, CAVITY TREES
few
many
TREE AGE
(relative to maximum longevity for species)
young
mature
old
AGE DISTRIBUTION OF TREES
even aged
uneven aged
SPECIES LONGEVITY
0
100
200
500
1000+
SUCCESSIONAL STATUS OF FOREST TYPE
seral
climax
AREA OF OLD GROWTH
small, fragmented
large, intact
CONNECTIVITY
isolated
connected
NATURAL CATASTROPHIC DISTURBANCE INTERVAL
frequent
infrequent
EXTENT OF ACCEPTABLE HUMAN MODIFICATION
post-establishment of stand (cutting, grazing, lack of fires)
high
low
pre-establishment of stand (clearcutting, agriculture, stripmining)
high
low

Figure 1.—*Model for the concept of old growth. Attributes representing the core concept of old growth are located at the hub of the wheel.*


Disturbance
Structure and Function
Landscape Function
Age
A
SITE TYPE
lowland
upland
forest
woodland
savanna
barrens
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TREE DENSITY
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large, intact
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pre-establishment of stand
(clearcutting, agriculture, stripmining)
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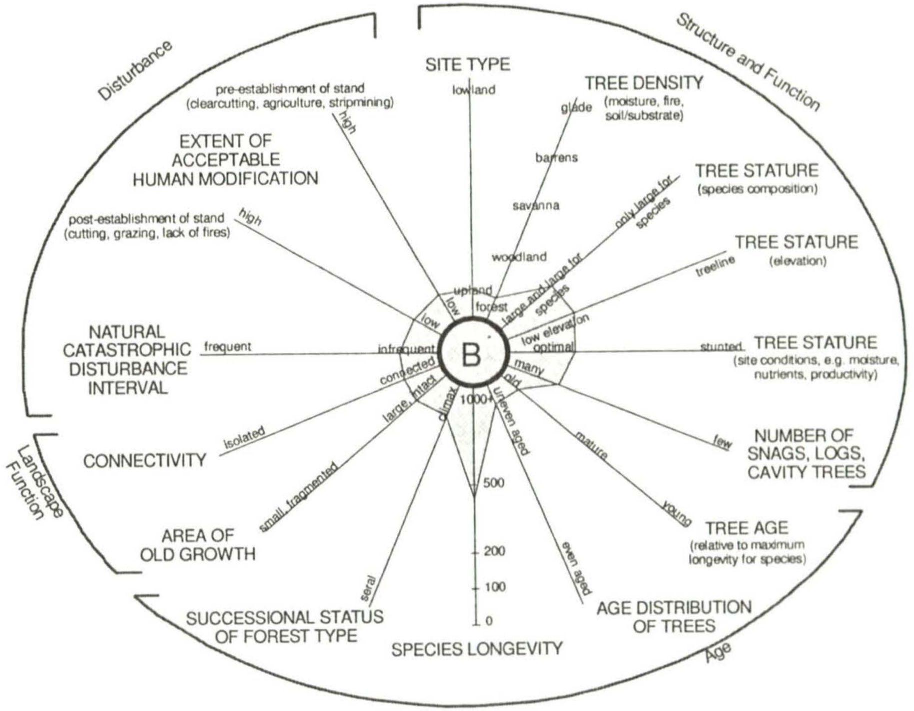
high
low


Disturbance
Structure and Function
Landscape Function
Age
B
SITE TYPE
lowland
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forest
woodland
savanna
barrens
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post-establishment of stand
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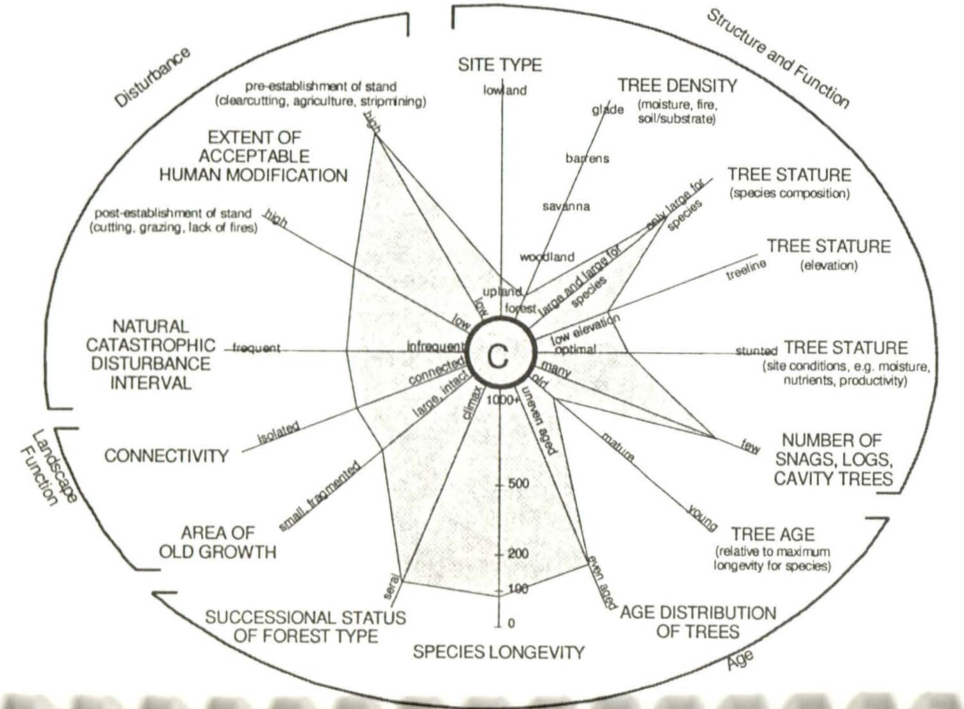
Disturbance
Structure and Function
Landscape Function
Age
C
SITE TYPE
lowland
upland
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pre-establishment of stand
(clearcutting, agriculture, stripmining)
post-establishment of stand
(cutting, grazing, lack of fires)
high
low

The polygons serve to systematically identify which spokes or axes seem to hold more weight with a particular view of old growth. In addition, any definition of old growth can be compared with the model to see which factors are included or emphasized and which are not.

The attributes or factors (clockwise from the top of the wheel) are: (1) SITE TYPE, (2) TREE DENSITY, (3) TREE STATURE (species composition), (4) TREE STATURE (elevation), (5) TREE STATURE (site conditions, *e.g.*, moisture, nutrients, productivity), (6) NUMBER OF SNAGS, LOGS, CAVITY TREES, (7) TREE AGE (relative to maximum longevity for species), (8) AGE DISTRIBUTION OF TREES, (9) SPECIES LONGEVITY, (10) SUCCESSIONAL STATUS OF FOREST TYPE, (11) AREA OF OLD GROWTH, (12) CONNECTIVITY, (13) NATURAL CATASTROPHIC DISTURBANCE INTERVAL, (14) EXTENT OF ACCEPTABLE HUMAN MODIFICATION (post-establishment of stand), and (15) EXTENT OF ACCEPTABLE HUMAN MODIFICATION (pre-establishment of stand). Attibutes are grouped by whether they relate to old-growth structure and function, age, landscape function, or disturbance.

Site Type.—Upland forests are more likely to correspond to our core concept of old growth (*e.g.*, northern hardwoods on upland sites) than lowland forests (*e.g.*, tamarack or black spruce swamps). In part, the smaller size of these lowland species may influence the concept. However, some lowland species such as northern white-cedar can attain impressive sizes (*e.g.*, Maine Critical Areas Program 1983b). In such cases (lowland site with large trees), there is likely to be some latitude in accepting as old growth a departure in this attribute from the core concept.

Tree Density.—Tree spacing may be influenced by soil moisture (such as at the forest-prairie border), fire frequency, and soil nutrients. In any case, natural communities with sparse trees are variously termed woodlands, savannas, barrens, and glades, depending on the local usage, tree densities, and plant associations involved. Closed canopy forests fit the core concept of old growth better than scattered trees, clusters of trees interspersed by prairie or rock outcrops, such as occur in a savanna, barrens, or glades landscape.

Tree Size (species composition).—Some species reach a larger size than others. Thus species composition influences the potential for trees to become large. Species with the potential to become large (*e.g.*, eastern white pine, eastern hemlock, sugar maple, American basswood) have more old-growthness than those species with smaller maximum sizes (*e.g.*, aspen, black spruce, fir, jack pine).

Tree Size (elevation).—Potential tree diameter and height are reduced with increasing elevation (Leak and Graber 1974). If large trees are one of the attributes of old growth, then old-growthness decreases with increasing elevation. If minimum criteria are set for old-growth forests (*e.g.*, red spruce-hardwoods), should the minimum criteria be modified for high-elevation forests? Is it necessary to be flexible about our core concept of old growth to allow old, smaller-statured forests at high elevations to be included as old growth?

Tree Size (site conditions, *e.g.*, moisture, nutrients).—In a similar way, maximum tree diameter and height are also influenced by site conditions. Rich sites that produce large trees can develop stands with more old-growthness than poor sites. Consider the photo of jack pine stunted by wind and salt spray on the Maine coast (see page 311). What size criteria would be appropriate for old-growth stands such as these? Likewise, are old, small trees on "stressful non-commercial sites" (Stahle 1996), *e.g.*, at the forest-prairie border or on rocky outcrops, still considered old growth if they don't meet some size criterion?

Examples of forest types whose trees are too small to conform to the core concept of old growth include some lowland boggy swamps, jack pine and aspen forests, xeric post oak savannas, and krumholtz spruce-fir at treeline or under other harsh conditions.

Snags, Logs, Cavity Trees.—Forests with more old-growthness have accumulated greater amounts of coarse woody debris in the form of logs and snags (Hale 1996, Stai and Mladenoff 1993, Tyrrell and Crow 1994). Cavities in snags or live trees, which are useful to wildlife, are also more abundant in old forests because of the increased susceptibility of trees to decay. Logs in all stages of decay are more likely to be present in old forests (Tyrrell and Crow 1994).

Tree Age (relative to maximum longevity for species).—At what age does a stand develop an old-growth character? That is, when does the transition from mature to old forest occur along the stand development timeline illustrated by Hunter (1990)? There is no consensus on an age criterion for old growth. Oliver and Larson (1996) suggest that true old growth does not occur until the last individual of a cohort established after a catastrophic event dies (trees present have all recruited from gap-phase replacement). In contrast, one criterion suggested for defining old growth uses half the maximum longevity for the species as the minimum age for old growth (Cogbill 1996). This criterion provides flexibility to account for differences in species longevity. If the trees are relatively old for that species, an old-growth condition may exist. Some species are capable of reaching the maximum longevity for the species on poor sites, while others are not. Should old forests growing on infertile sites where trees may never reach the longevity possible on richer soils (*i.e.*, never would attain the half-maximum age) be subject to a different set of standards? Does the concept of old growth (and the criteria used to define it) need to be adjusted based on management objectives if few current stands meet the age criterion (see discussion by Hunter and White 1997)?

Age Distribution of Trees.—Old-growth landscapes are a natural mosaic of stands of different ages produced by the patchiness of natural disturbance (*e.g.*, Frelich and Graumlich 1994, Frelich and Lorimer 1991). While old-growth stands predominate in an old-growth landscape, areas of younger trees produced by wind, fire, insect damage, or individual tree mortality are likely to be present as well. Old forests typically have more old-growthness if they are uneven-aged rather than even-aged. Even-aged patches, however, may occur in an old-growth landscape due to natural disturbance.

Species Longevity.—The core concept of old growth usually connotes long-lived species rather than short-lived ones. Thus old forests of eastern white pine, red pine, eastern hemlock, American basswood, sugar maple, and red oaks are generally considered to have more old-growthness than old forests of jack pine, balsam fir, or aspen.

Successional Status of Forest Type.—Some old-growth forests may remain on a site over decades or millenia (*e.g.*, Frelich *et al.* 1993). Relatively shade-tolerant "climax" species can regenerate in the understory of current old growth. Long-lived, self-replacing, climax, steady-state forests (*e.g.*, as illustrated in a general plant ecology text—Barbour *et al.* 1987) would be considered old growth without debate. Old stands of northern hardwoods, conifer-northern hardwoods, and beech-maple-basswood are often viewed as illustrating the core concept of old growth better than seral communities, such as white or red pine, some oaks, and aspen, that are likely to be replaced by more mesic or shade-tolerant species. However, whether old early- and mid-seral forests qualify as old growth is less clear (see Frelich 1995).

Area of Old Growth.—Relatively undisturbed landscapes are often dominated by old growth in a variety of patch (stand) sizes including large contiguous ones (Mladenoff *et al.* 1994). Compared to unmodified landscapes, landscapes modified by timber harvesting and land development have fewer (if any) large patches of old growth (Mladenoff *et al.* 1994).

Connectivity.—In landscapes that correspond to a core concept of old growth, stands are relatively near each other and connected with closed-canopy forest. In highly modified landscapes, any patches of old growth are not only small but also isolated from each other (*e.g.*, Mladenoff *et al.* 1994, Spetich *et al.* 1997).

Natural Disturbance.—Forest composition, structure, and landscape patterns are all related to natural disturbances. Tree species have adapted to the disturbance regimes they evolved with. Tree longevity, in particular, appears to be related to cycles of natural disturbance (Cogbill 1996). For example, short-lived, pioneer species prevail in even-aged forests where frequent, high-intensity disturbances occur (*e.g.*, jack pine or aspen). Because of their short life spans and successional status, these forests are usually not considered old growth. Other terms, such as old-seral forests (Frelich 1995), are often used to describe older examples of these forests. In contrast, forests composed of long-lived, gap-phase species occur where high-intensity catastrophic disturbances are infrequent (*e.g.*, beech-maple-basswood, conifer-northern hardwoods). With long intervals between disturbances, large, old trees can develop on the site. These are the forests normally thought of and referred to as old growth (Frelich 1995) and would be part of our core concept of old growth.

Mladenoff and Pastor (1993) developed a conceptual graph with axes representing frequencies of fire and damaging wind. Forest types are graphed according to the disturbance regime they experience. Forest types plotted near the origin (low fire and wind frequencies) are more likely to develop old-growth attributes than those farther away. The core concept of old growth would more easily apply to old forests of these types. For example, because northern hardwoods experience a low frequency of fire and wind, the ellipse for this forest type is located near the origin. In contrast, jack pine forests are located high on the fire frequency axis. Oak and pine systems might occur at intermediate distances along the fire-frequency axis. Somewhere along the axis of catastrophic disturbance frequency, there will be a point where most would argue that the frequency of disturbance precludes the development of old growth. Where is this point?

Extent of Acceptable Human Modification (pre-establishment of stand).—Conversion to pasture or agriculture constitutes severe disturbance to forest ecosystems (Hunter and White 1997). Succession in abandoned old-fields may result in forests that eventually take on some of the characteristics of old growth. However, centuries may be needed for these forests to acquire sufficient structural and functional attributes to be considered old growth (Hunter and White 1997). Forests that develop after such agricultural uses or after clearcuts do not have as much old-growthness as primary forests (Noss and Cooperrider 1994). Nonetheless, in the East, thinking in longer timeframes may be needed to allow time for old growth to develop.

Extent of Acceptable Human Modification (post-establishment of stand).—It is clear that heavy logging or thinning does not leave old growth on a site, and old forests that have not been modified by humans (relatively "pristine" primary forests) are old growth. However, there is no consensus as to how much human modification or disturbance can occur and still retain the old-growth character of the forest (Hunter and White 1997). For example, 100-year-old northern hardwood even-age rotations contain fewer wildlife habitat features (such as cavities, excavations, and "escapes") than do natural old-growth stands (Burns and McGee 1997). Severe human disturbance (*e.g.*, clearcutting) can cause long-term degradation to ground flora, thus prolonging the time for human-modified stands to revert to old growth (Duffy and Meier 1992). Old forests comprised of native species have more old-growthness than those invaded by non-native plants and animals (Noss and Cooperrider 1994).

Complications in Defining Old Growth

As indicated in the previous section, there are a number of difficulties with defining old growth either conceptually or practically, including: (1) lack of consensus as to which forest types occur in an old-growth condition; (2) difficulty in selecting attributes and criteria by which to define old growth; (3) variation in species size and spacing due to site, soils, topography, or other geographic or local differences; (4) lack of available data to describe old-growth conditions; (5) questionable representativeness of remnant stands; (6) changes in forest structure due to altered disturbance regimes since European settlement; (7) the influence of pollution, exotics, fragmentation, and extinctions; and (8) the need to move beyond stand-level definitions to consider landscapes. Items (1) through (3) have been previously discussed.

Lack of Data

Without data on structural aspects of old growth spanning young, mature, and older stages of forest development, it is difficult to determine when a forest transitions from mature to old growth. If minimum guidelines for old growth are based on data from young or moderately old "old-growth" forests, what structural and functional diversity are we missing that only occurs in forests with highly developed old-growthness?

Questionable Representativeness of Remnant Examples

The old growth that remains relatively unmodified in the East consists primarily of small, isolated stands (Davis 1993). Some areas have not been logged due to inaccessibility, others due to some other oddity about the stand. Thus it is possible, even likely, that extant old-growth examples are not representative of the range of old-growth conditions that occurred before Euro-American settlement. Those examples that do exist may be too small and isolated to maintain the functional attributes of old growth. In addition, altered disturbance regimes may cause remnants to be unrepresentative of the old growth that dominated former landscapes (see below).

Altered Disturbance Regimes

Most landscapes previously subject to extensive periodic fires no longer experience such burns (*e.g.*, Abrams 1992). Both fire suppression efforts and forest fragmentation (fires cannot travel as they once could due to discontinuous fuel) contribute to this current condition. In contrast, some landscapes have been burned more intensely or more frequently as a result of logging.

A dry oak forest in the Mark Twain National Forest illustrates the dilemma associated with trying to define old growth for forest types with modified disturbance regimes. Originally, large, old post oaks were widely spaced in savannas. A decrease in fire frequency since European settlement has modified the forest structure and composition. Now, small, young black oaks and hickories have filled in the spaces among the post oaks. There is no longer an intact, high-quality savanna to serve as a model for old-growth post oak savanna. Even if we were able to develop a definition based on historical reconstructions, would the extant forest be considered a degraded old-growth savanna or a young black oak forest that is not old growth? There are problems in both developing and applying a definition.

Influence of Pollution or Exotics

In developing old-growth definitions, how should we deal with more dead wood present in many forests due to increased mortality from air pollution, and exotic pathogens and insects. Fraser fir death from the woolly adelgid in the Great Smoky Mountains illustrates this problem. The composition of forests today is much different than decades ago as evidenced by the effects of Dutch elm disease and chestnut blight. How will the composition change due to beech bark disease, dogwood anthracnose, hemlock woolly adelgid, and gypsy moth?

Need to Consider Landscapes

Even though practical definitions of old growth tend to be based on tree characteristics and stand properties, looking at old growth from the tree or stand level is only seeing a small part of the picture. While old growth can be described at various spatial scales, old growth is more than big, old gnarly trees. Old growth is more than small isolated forest stands. Perhaps establishing criteria for defining old growth at a landscape scale would be more fruitful than separately defining adjacent stands of old growth that fall within different forest type groups. For example, a complex of old-growth stands including northern hardwoods, spruce-fir, spruce-northern hardwoods, and northern white-cedar all occur within the same old-growth landscape at the Big Reed Pond preserve in northern Maine (Cogbill 1985, Widoff 1985). Different forest types can occur close together because forest composition, tree size, and site productivity can differ radically along soil or topographic gradients and slope aspect differences (*e.g.*, see diagram for forests on slopes in southern Illinois (Fralish *et al.* 1991)).

Old-growth landscapes are dominated by old growth but also incorporate patterns of natural disturbance such as the fir waves illustrated in a New England landscape (Sprugel and Bormann 1981). Taken at the stand level, only older portions of the fir wave would be considered old growth, whereas, considering the landscape as a whole, the entire landscape, if relatively undisturbed by humans, could be considered old growth. Younger patches of recently disturbed forest would be interspersed in the older matrix (Sprugel 1976).

Summarizing the Old-Growth Dilemma

(1) There are both conceptual and practical ways to define old growth.

(2) There are problems with converting western old-growth definitions to the eastern United States.

(3) Various eastern old-growth definitions exist but there is no consensus on the concept of old growth.

(4) A model of old-growth attributes can help visualize the difficulties in establishing boundaries to a core concept of old growth.

(5) Several complications exist with trying to define old growth.

DO WE NEED OLD-GROWTH DEFINITIONS?

Concept of Old Growth

To recap the core concept of old growth, old-growth forests are those forests that are relatively old and relatively undisturbed (Hunter 1989). The complex structural and functional characteristics associated with old growth have developed over long periods of time with minimal disturbance. The core concept of old growth applies most readily to long-lived species (*e.g.*, northern hardwood species, eastern hemlock, most oaks, eastern white pine, red pine, and lowland conifer species such as northern white-cedar) on low-elevation, productive sites.

Current Condition of Eastern Forests

Forested landscapes of the eastern United States have been modified dramatically since European settlement (*e.g.*, Whitney 1994, Andersen *et al.* 1996, Silbernagel *et al.* 1997). The extent of the eastern forest has been reduced by agriculture and urbanization despite reforestation in New England and the South. Extensive logging has replaced predominantly old forests with young forests. Changes in composition, including a greater abundance of successional species such as aspen, have occurred (Graham *et al.* 1963). And finally, spatial patterns have been altered—the current forest is more fragmented than in the past (Mladenoff *et al.* 1994, Spetich *et al.* 1997).

Old-growth forests, by any definition, are rare in the East (Davis 1993). In the Lake States, for example, approximately 32.7 million ha of closed-canopy forests existed at the time of the General Land Office (GLO) survey in the nineteenth century; Frelich (1995) estimates that 22.3 million ha of this total was old growth. At present, only forests in the Boundary Waters Canoe Area Wilderness in northern Minnesota and the Porcupine Mountains State Park, McCormick and Sylvania Wilderness Areas, and the Huron Mountain Club in northern Michigan retain some semblance of the composition, structure, and spatial pattern associated with upland forests before Euro-American settlement (Simpson *et al.* 1990, Frelich 1995).

At present, few primary forest stands 200, 300, or 400+ years old exist, although tree species comprising these forests are capable of such life spans (*e.g.*, for hemlock, Tyrrell and Crow 1994). Some current old-growth stands are located in inaccessible, rugged areas (Nowacki and Trianosky 1993), while others exist on infertile, xeric, or saturated sites (*e.g.*, Stahle 1997). Most of today's old growth are stands that have been selectively logged (high-graded), or second-growth stands reaching old age (*e.g.*, Schmidt *et al.* 1996) or with scattered remnant old trees (*e.g.*, Nowacki and Abrams 1994). Some stands designated as old growth on national forests are second-growth forests that are approximately 100 to 120 years old (Tyrrell 1996).

Is There a Need for Minimum Standards or Definitions?

Criteria that "define" old growth (operational definitions) may be useful for:

(1) Inventorying stands to determine which have few or many old-growth characteristics.

(2) Prioritizing sites for protection and allocation to old growth (higher priority given to stands with more old-growth characteristics).

(3) Determining whether or when forests that are not currently old growth acquire an old-growth condition in the future.

Criteria for Definitions

The following criteria are fairly easy to apply and thus commonly appear in definitions used to assess the old-growth condition of a forest or help select near-old growth for allocation (*e.g.*, Rusterholz 1996):

- age of stand
- lack of human disturbance (*e.g.*, few stumps, no recent entry for thinning or harvesting, no grazing)
- lack of catastrophic natural disturbance

Criteria based on structural characteristics (trees, logs, snags, gaps) tend to imply that silvicultural techniques can be used to develop or maintain old-growth forests while continuing to produce commodities. Silvicultural manipulations can indeed create or accelerate the formation of some of the structural attributes of old growth (Nyland 1997): produce large trees through crown release (see also Goodburn and Lorimer 1997, Singer and Lorimer 1997), maintain an irregular upper canopy, increase vertical structural diversity, create snags, mimic gap dynamics (see also Runkle 1991), and increase age diversity. Other practices, such as adding nest boxes or dead logs, provide habitat associated with old growth (Runkle 1991). However, some old-growth characteristics prevail only with sufficient time. For example, it takes time for abundant coarse woody debris to develop even with silvicultural manipulations (Goodburn and Lorimer 1997), and for logs to reach advanced stages of decay (Tyrrell and Crow 1994).

Management options such as big-tree silviculture and managing for some old-growth characteristics, as well as extended rotations and selection harvests, are useful complements to unmanaged old growth. Stands that mimic important old-growth conditions provide several of the values commonly attributed to old-growth stands and can be used effectively as buffers around old-growth stands (Nyland 1997). These management techniques, however, do not produce the full array of old-growth characteristics and do not result in old growth. Young forests manipulated to provide some old-growth structural features are no substitute for old growth (Runkle 1991). Runkle also argues that "possibilities for making younger stands more nearly resemble old-growth forests should not be used as an excuse to log old-growth forests."

Any criteria used to define old growth should be developed and applied in the context of local and regional site conditions. That is, criteria must be adjusted according to the forest type (composition), the quality of the site, and regional or local factors such as climate, soils, and elevation. Old-growth criteria also need to be developed with management objectives clearly stated. For example, Hunter and White (1997) caution that when defining old growth to conserve extant old-growth stands a balance should be struck between using criteria that are too conservative, such that few stands meet the standards for protection, and those that are too liberal, such that too many sites are considered old growth.

Land Allocations for Old Growth

Both stand and landscape factors need to be considered when developing goals and strategies for designating old growth. These factors include assuring that old growth is represented in the major ecosystems such as those defined in the USDA Forest Service's National Hierarchical Framework for Ecological Units (Bailey *et al.* 1993, ECOMAP 1993, Avers *et al.* 1994, Keys *et al.* 1995, McNab and Avers 1994). Stands selected should be old for the species (*i.e.*, older than the average age for managed forests) and should be relatively undisturbed (*e.g.*, few roads and stumps). The designated areas will need to be protected from timber harvesting and salvage following natural disturbance, and instead be managed to include natural disturbance as a long-term ecological reference area.

Old-growth characteristics take time to develop, but old-growth forests do not last forever due to successional changes with seral communities (*e.g.*, a mature stand of red pine converts to hardwoods) or catastrophic disturbance. Thus planning for "replacement stands" should be part of the allocation process.

Planning for "replacement stands" is a landscape consideration. Other landscape factors to consider are: (1) the broad landscape context in which an old-growth area exists; (2) the shape and size of the old-growth area; (3) linkages between the designated area and other areas with management for natural processes (*i.e.*, research natural areas, special interest areas, wilderness areas, wild and scenic river corridors); and (4) the possibility of co-designation with compatible areas.

Old-growth "definitions" should be used as general guidelines but not as absolute criteria or as minimal standards. That is, allocations should consider the best old-growth or near-old-growth conditions that exist, but also consider landscape context and function. For example, in selecting stands for old growth, or more accurately, future old growth, a small, isolated 100-year-old stand may be by-passed in favor of an 80-year-old stand if the 80-year-old stand is larger, less disturbed, and adjacent to a non-motorized area.

To provide for the protection and maintenance of community and landscape diversity, to provide ecological reference areas to aid in understanding and managing ecosystems, and to provide the full spectrum of old-growth values, **old-growth allocations should avoid:**

- overrepresentation of non- or low-productive land
- counting non-forested areas as old growth in old-growth landscapes
- overrepresentation of short-lived successional species
- shifting of old-growth allocations as stands produce marketable timber

Principles for Communicating About Old Growth

There are various complications involved in defining old growth. And yet definitions are useful in inventorying existing old growth, prioritizing sites for allocation to old growth, and assessing the acquisition of old-growth characteristics by a stand over time. To bridge the chasm between the lack of consensus about old-growth concepts and the public mandate to plan for and manage public land to include old-growth stands in the landscape, the following guidelines are recommended.

(1) Clearly state the objectives of any old-growth definition.

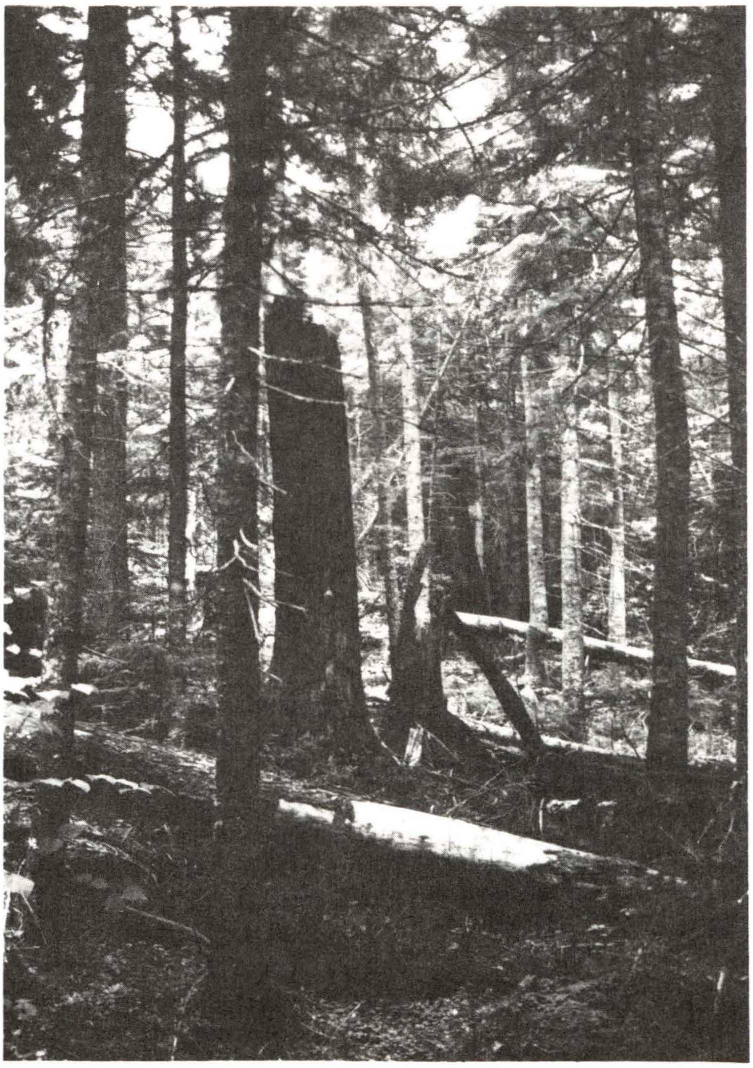
(2) Clarify the conceptual definition and make any operational (practical) definition congruent with it. (This may also mean clarifying which forest types occur in an old-growth condition).

(3) Present any limitations to the development or use of the definition.

(4) Allow flexibility for modifying the definitions as concepts of old growth change or even as the ecosystems themselves undergo change.

An increased ecological understanding of old growth, through study of remnant stands and historical reconstructions, and continued discussions of old growth in relation to management objectives, along with refinement of the old-growth core concept, may ultimately provide additional guidance as to what constitutes old growth.

HOW TO USE THIS PUBLICATION



▲ ***Nancy Brook Research Natural Area**, White Mountain National Forest, New Hampshire. Coarse woody debris (in the form of snags and logs) is readily apparent in this montane red spruce-balsam fir stand. See Carbonneau (1986a) and Leak (1986b). Photo 7/92 by Lucy Tyrrell.*

GUIDE TO TEXT FOR FOREST TYPE GROUPS

We present information for nine forest type groups—three dominated by hardwoods, one that is a mixture of conifers and hardwoods, and three dominated by conifers. The forest type groups are arranged in alphabetical order by name within each category (hardwoods, mixed, and conifers) (see Table 1). Hardwood-dominated groups are: beech-maple-basswood, northern hardwood, oak (dry and xeric), oak (mesic and wet-mesic northern), and wetland (hardwood). The mixed group is conifer-northern hardwood. Conifer-dominated groups are pine (northern), spruce-fir (montane and allied), and spruce-fir (subboreal).

FOREST TYPE GROUPS

For each forest type group, we include: COMMUNITY COMPOSITION, PHYSICAL CONTEXT, DISTURBANCE, RELATION TO OTHER FOREST TYPES, STRUCTURAL CHARACTERISTICS OF OLD-GROWTH STANDS, SELECTED REPRESENTATIVE OLD-GROWTH STANDS, and FOR ADDITIONAL INFORMATION.

The COMMUNITY COMPOSITION, PHYSICAL CONTEXT, DISTURBANCE, RELATION TO OTHER FOREST TYPES, and FOR ADDITIONAL INFORMATION sections provide general information about the forest type groups, regardless of age or old-growthness. These sections help classify a particular stand by forest type group.

More specific information about the characteristics associated with old-growth conditions is contained in the sections STRUCTURAL CHARACTERISTICS OF OLD-GROWTH STANDS and SELECTED REPRESENTATIVE OLD-GROWTH STANDS.

The information for each forest type group is identified as a set by color pages. Note that reference numbers (MAP KEY) are assigned within a particular forest type group and are used in all tables and the figure for that group.

COMMUNITY COMPOSITION

To help determine the appropriate forest type group for a particular stand, refer to Table 1 (a list of all the forest type groups found in the Forest Service's Eastern Region), or to Appendix A (a list of forest type groups found in the eastern United States). Additional information about differences in composition among forest type groups is contained in the section RELATION TO OTHER FOREST TYPE GROUPS. The source for common and scientific names of tree species is Little (1979).

Forest Cover Types

We list the Society of American Foresters (SAF) forest cover types (Eyre 1980) that fall within the forest type group. Some SAF cover types occur in two or more forest type groups (*e.g.*, SAF 27 - sugar maple falls into northern hardwoods, beech-maple basswood, and mixed mesophytic). *Note:* To aid in determining to which forest type group(s) a given SAF cover type group belongs, we also provide a list of which forest type groups (old-growth groups as used in this publication) correspond to each SAF cover type (Table 2).

We also list which Combined Data Systems (CDS) forest cover types used by the Forest Service Eastern Region (USDA Forest Service 1974) fall within the forest type group. A comparison of CDS forest cover types and forest type groups (as used in this publication) is given in Table 3.

Species Composition

Variation in species composition in different parts of the geographic range is described for the forest type group. For example, beech is absent from the beech-maple-basswood forest type group in the western part of the Lakes States (western Wisconsin and Minnesota), and there the forest type is really maple-basswood. In montane spruce-fir forests, Fraser fir and balsam fir occur in the southern and northern parts of the Appalachian Mountain range, respectively.

Knowing about variation in species composition within the forest type group is important when interpreting information on old-growth attributes. Differences in species composition and abundance influence potential size of trees, which in turn affects maximum diameter, diameter distribution, density, and basal area. Species composition also affects maximum tree longevity, susceptibility of trees to pathogens, rate of snag formation and decay,

Table 2.—*Comparison between Society of American Forester (SAF) forest cover types (Eyre 1980) occurring in the USDA Forest Service Eastern Region and forest type groups as used in this publication.*

SAF Forest Cover Type	Forest Type Group
1 - Jack pine	Northern pine
5 - Balsam fir	Montane and allied spruce-fir Subboreal spruce-fir
12 - Black spruce	
>subtype a	Subboreal spruce-fir
>subtype b	Subboreal spruce-fir
>subtype c	Subboreal spruce-fir
>subtype d	Northern conifer wetland
>subtype e	Northern conifer wetland
>subtype f	Northern conifer wetland
13 - Black spruce-tamarack	Northern conifer wetland
14 - Northern pin oak	Dry and xeric oak
15 - Red pine	Northern pine
16 - Aspen	Aspen-birch[1]
17 - Pin cherry	[1]
18 - Paper birch	Aspen-birch[1]
19 - Gray birch-red maple	Aspen-birch[1]
20 - White pine-northern red oak-red maple	Conifer-northern hardwood
21 - Eastern white pine	Conifer-northern hardwood Northern pine
22 - White pine-hemlock	Northern pine
23 - Eastern hemlock	Conifer-northern hardwood
24 - Hemlock-yellow birch	Conifer-northern hardwood
25 - Sugar maple-beech-yellow birch	Mixed and western mesophytic Northern hardwood
26 - Sugar maple-basswood	Beech-maple-basswood
27 - Sugar maple	Beech-maple-basswood Mixed and western mesophytic Northern hardwood

(Table 2 continued on next page)

(Table 2 continued)

SAF Forest Cover Type	Forest Type Group
28 - Black cherry-maple	Northern hardwood
30 - Red spruce-yellow birch	Conifer-northern hardwood Montane and allied spruce-fir
31 - Red spruce-sugar maple-beech	Conifer-northern hardwood
32 - Red spruce	Montane and allied spruce-fir
33 - Red spruce-balsam fir	Montane and allied spruce-fir
34 - Red spruce-Fraser fir	Montane and allied spruce-fir
35 - Paper birch-red spruce-balsam fir	Conifer-northern hardwood Montane and allied spruce-fir
37 - Northern white-cedar	Northern conifer wetland Rocky, thin-soiled cedar
38 - Tamarack	Northern conifer wetland
39 - Black ash-American elm-red maple	Hardwood wetland
40 - Post oak-blackjack oak	Dry and xeric oak Great Plains riparian hardwood Seasonally wet oak-hardwood
42 - Bur oak	Dry and xeric oak Mesic and wet-mesic northern oak
43 - Bear oak	Dry and xeric oak Xeric pine and pine-oak
44 - Chestnut oak	Dry and xeric oak Dry-mesic oak
45 - Pitch pine	Northern pine Xeric pine and pine-oak
46 - Eastern redcedar	Rocky, thin-soiled cedar
50 - Black locust	[2]
51 - White pine-chestnut oak	Dry and dry-mesic oak-pine Xeric pine and pine-oak
52 - White oak-black oak-northern red oak	Dry-mesic oak Mesic and wet-mesic northern oak Mixed and western mesophytic

(Table 2 continued on next page)

(Table 2 continued)

SAF Forest Cover Type	Forest Type Group
53 - White oak	Coastal plain upland mesic hardwood Dry-mesic oak Mesic and wet-mesic northern oak Seasonally wet oak-hardwood
55 - Northern red oak	Dry-mesic oak Mesic and wet-mesic northern oak
57 - Yellow-poplar	Mixed and western mesophytic
58 - Yellow-poplar-eastern hemlock	Mixed and western mesophytic
59 - Yellow-poplar-white oak-red oak	Mixed and western mesophytic
60 - Beech-sugar maple	Beech-maple-basswood Mixed and western mesophytic Northern hardwood
61 - River birch-sycamore	Eastern riverfront
62 - Silver maple-American elm	Eastern riverfront
63 - Cottonwood	Eastern riverfront
64 - Sassafras-persimmon	[2]
65 - Pin oak-sweetgum	Hardwood wetland River floodplain hardwood Seasonally wet oak-hardwood
75 - Shortleaf pine	Dry and dry-mesic oak-pine Xeric pine and pine-oak
76 - Shortleaf pine-oak	Dry and dry-mesic oak-pine Xeric pine and pine-oak
78 - Virginia pine-oak	Dry and dry-mesic oak-pine Xeric pine and pine-oak
79 - Virginia pine	Dry and dry-mesic oak-pine Xeric pine and pine-oak
87 - Sweetgum-yellow-poplar	River floodplain hardwood
88 - Willow-water-diamondleaf oak	River floodplain hardwood Seasonally wet oak-hardwood
91 - Swamp chestnut oak-cherrybark oak	River floodplain hardwood

(Table 2 continued on next page)

(Table 2 continued)

SAF Forest Cover Type	Forest Type Group
92 - Sweetgum-willow oak	River floodplain hardwood
93 - Sugarberry-American elm-green ash	River floodplain hardwood
94 - Sycamore-sweetgum-American elm	Eastern riverfront River floodplain hardwood
96 - Overcup oak-water hickory	River floodplain hardwood
97 - Atlantic white-cedar	Atlantic white-cedar
101 - Baldcypress	Cypress-tupelo
102 - Baldcypress-tupelo	Cypress-tupelo
103 - Water tupelo-swamp tupelo	Cypress-tupelo
107 - White spruce	Subboreal spruce-fir
108 - Red maple	Hardwood freshwater tidal Hardwood wetland River floodplain hardwood
109 - Hawthorn	[1, 2]
110 - Black oak	Dry and xeric oak Dry-mesic oak
236 -Bur oak	Dry and xeric oak Great Plains riparian hardwood

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[1] This forest cover type may not exist in an "old-growth" condition, because trees are small, short-lived, or are of a pioneer, successional species.

[2] This tree species or species group represents an "unnatural" forested system resulting from recent human manipulation or presence of non-native species.

Table 3.—*Comparison between Combined Data Systems (CDS) forest cover types occurring in the Forest Service Eastern Region and forest type groups as used in this publication.*

Eastern Region Combined Data Systems (CDS) Forest Cover Type	Forest Type Group
1 - Jack pine	Northern pine
2 - Red pine	Northern pine
3 - White pine	Northern pine
4 - White pine/hemlock	Conifer-northern hardwood
5 - Hemlock	Conifer-northern hardwood
9 - Conifers	Conifer-northern hardwood Northern pine
11 - Balsam fir/aspen/paper birch	Subboreal spruce-fir
12 - Black spruce	Northern conifer wetland Subboreal spruce-fir
13 - Red spruce/balsam fir	Montane and allied spruce-fir
14 - Northern white-cedar	Northern conifer wetland Rocky, thin-soiled cedar
15 - Tamarack	Northern conifer wetland
16 - White spruce/balsam fir/Norway spruce	[1, 2]
17 - Upland black spruce	Subboreal spruce-fir
19 - Cedar/aspen/paper birch	[1]
32 - Shortleaf pine	Dry and dry-mesic oak-pine Xeric pine and pine-oak
33 - Virginia pine	Dry and dry-mesic oak-pine Xeric pine and pine-oak
35 - Eastern redcedar	Rocky, thin-soiled cedar
38 - Pitch pine	Dry and dry-mesic oak-pine Northern pine Xeric pine and pine-oak
41 - White pine/northern red oak/white ash	Conifer-northern hardwood
42 - Eastern redcedar/hardwood	Rocky, thin-soiled cedar Dry and dry-mesic oak-ine

(Table 3 continued on next page)

(Table 3 continued)

Eastern Region Combined Data Systems (CDS) Forest Cover Type	Forest Type Group
44 - Shortleaf pine/oak	Xeric pine and pine-oak
48 - Jack pine/oak	Northern pine Xeric pine and pine-oak
49 - Red pine/oak	Northern pine Seasonally wet oak hardwood
52 - Chestnut oak	Dry-mesic oak Dry and xeric oak
53 - Black oak/scarlet oak/hickory	Mesic and wet-mesic northern oak
54 - White oak	Coastal plain upland mesic hardwood Dry-mesic oak Mesic and wet-mesic northern oak
55 - Northern red oak	Dry-mesic oak Mesic and wet-mesic northern oak
56 - Yellow-poplar/white oak/northern red oak	Dry-mesic oak Mixed and western mesophytic
57 - Scarlet oak	Dry and xeric oak
58 - Sweetgum/yellow-poplar	River floodplain hardwood
59 - Mixed oaks	Dry and xeric oak Dry-mesic oak Mesic and wet-mesic northern oak Seasonally wet oak hardwood
61 - Swamp chestnut/cherrybark/pin oak	River floodplain hardwood
62 - Sweetgum/Nuttall's oak/willow oak	River floodplain hardwood
67 - Baldcypress/Water tupelo	Cypress-tupelo
71 - Black ash/American elm/red maple	Hardwood wetland
72 - River birch/sycamore	Eastern riverfront
73 - Cottonwood	Eastern riverfront
75 - Sycamore/pecan/American elm	Eastern riverfront
76 - Red maple (wet site)	Hardwood wetland River floodplain hardwood

(Table 3 continued on next page)

(Table 3 continued)

Eastern Region Combined Data Systems (CDS) Forest Cover Type	Forest Type Group
77 - Green ash	Eastern riverfront River floodplain hardwood
78 - Black walnut	Eastern riverfront River floodplain hardwood
79 - Mixed lowland hardwoods	Eastern riverfront Hardwood wetland River floodplain hardwood
81 - Sugar maple/beech/yellow birch	Mixed and western mesophytic Northern hardwood
82 - Sugar maple/basswood	Beech-maple-basswood
83 - Black cherry/white ash/yellow-poplar	Mixed and western mesophytic
84 - Red maple (dry site)	Dry-mesic oak
85 - Sugar maple	Beech-maple-basswood Mixed and western mesophytic Northern hardwood
86 - Beech	Beech-maple-basswood
87 - Sugar maple/beech/yellow birch/red spruce	Northern hardwood Conifer-northern hardwood
88 - Black locust	[2]
89 - Mixed hardwoods	Mesic and wet-mesic northern oak Northern hardwood
91 - Quaking aspen	[2]
92 - Paper birch	Aspen-birch[2]
93 - Bigtooth aspen	Aspen-birch[2]
94 - Balsam poplar	[2]
95 - Aspen-white spruce-balsam fir	Aspen-birch[2]
97 - Lowland brush	—
98 - Upland brush	—
99 - Open	—

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[1] This tree species or species group represents an "unnatural" forested system resulting from recent human manipulation or presence of non-native species.

[2] This forest cover type may not exist in an "old-growth" condition, because trees are small, short-lived, and are of a pioneer, successional species.

and rate of log decay. Tree species included in the attribute tables for tree age, tree diameter, and canopy height are listed in Table 4 (alphabetically by common name) and Table 5 (alphabetically by scientific name).

PHYSICAL CONTEXT

Physiographic Provinces

The physical factors that influence the vegetation present on a site are described using Fenneman's (1938) physiographic provinces, with qualifying remarks about sections of the provinces. For example, beech-maple-basswood exists in the Coastal Plain physiographic province (among others), but only in the Embayed section of this province.

Ecological Units

Which ecological units of the National Hierarchy of Ecological Units (ECOMAP 1993) contain the forest type group? We provide a preliminary list of the domain, division, and province classifications for the range of the forest type group.

Geographic Distribution

In which geographical area does a forest type group occur? Distribution of the forest type group is described in political terms (states) and in geographic terms (mountain range, glacial limit).

Soils

Soils are described for the forest type group. If the group is broad and variable, soils may be described for subgroups of the forest type (*e.g.*, for conifer-northern hardwoods, we describe soils for eastern white pine-dominated areas in addition to eastern hemlock-dominated areas).

DISTURBANCE

Knowledge of disturbance patterns for the forest type group is important because the intensity and frequency of disturbance (*e.g.*, fires, tornados, hurricanes, downbursts, ice storms, and floods) influence stand structure, species composition, successional patterns and potential stand longevity. Most, if not all, eastern forests have been modified to some extent by Native American activities; while these influences are important, they are not discussed at length here. Other human influences (logging, fires, fire suppression, introduction of exotics, pollution, and fragmentation) are discussed as they relate to changes in forest age, composition, and stand structure, including presence and amounts of dead wood.

RELATION TO OTHER FOREST TYPES

It is often difficult to assign forests to their appropriate forest type group because of variation in composition within the geographic range of each group. This section provides some guidance in classifying stands by forest type groups by pointing out similarities and differences among forest type groups (see also Fig. 3). Again, referring to Table 1 may help, as it presents the complete list of forest type groups found in the Eastern Region of the Forest Service. Referring to Appendix A (list of all forest type group in the East) may help the reader identify which forest type group fits a stand.

STRUCTURAL CHARACTERISTICS OF OLD-GROWTH STANDS

We list here the figure (map) and tables that pertain to the forest type group. The figure and tables were compiled from studies that recorded data for the forest type group in an old-growth condition.

SELECTED REPRESENTATIVE OLD-GROWTH STANDS

Examples of forests in an old-growth condition are listed alphabetically by state. This list is by no means exhaustive. In some cases additional information is given (*e.g.*, National Forest, county).

For the most part, our lists are based on old growth extant at the time of writing. However, there is no guarantee that the old-growth examples remain relatively undisturbed. Changes in ownership, management, or natural disturbance may have affected some stands. In addition, we may not have been aware that some old-growth stands had been logged or blown down before we compiled our list and thus we included them.

We listed a few general areas (*e.g.*, Shenandoah Valley, see page 179). In these cases, the entire area is not old growth, but includes some stands of old growth.

Table 4.—*Common and scientific names of trees included in the attribute tables for tree age, diameter, and canopy height. Names follow Little (1979).*

Common Names	Scientific Names	Beech-Maple-Basswood	Northern Hardwood	Oak, Xeric	Oak, Mesic Northern	Wetland, Hardwood	Conifer-Northern Hardwood	Pine, Northern	Spruce-fir, Montane	Spruce-fir, Subboreal
Ash, black	*Fraxinus nigra* Marsh.				X	X				
Ash, white	*Fraxinus americana* L.		X		X		X			
Aspen	*Populus* L.						X			
Aspen, bigtooth	*Populus grandidentata* Michx.							X		
Basswood, American	*Tilia americana* L.	X	X					X		
Beech, American	*Fagus grandifolia* Ehrh.	X	X		X		X			
Birch, paper	*Betula papyrifera* Marsh.							X		X
Birch, yellow	*Betula alleghaniensis* Britton		X			X	X		X	
Blackgum or black tupelo	*Nyssa sylvatica* Marsh.					X				
Cherry, black	*Prunus serotina* Ehrh.		X							
Elm	*Ulmus* L.	X	X			X				
Elm, American	*Ulmus americana* L.				X					
Fir, balsam	*Abies balsamea* (L.) Mill.						X	X	X	X
Fir, Fraser	*Abies fraseri* (Pursh) Poir.								X	
Hemlock, eastern	*Tsuga canadensis* (L.) Carr.		X			X	X	X		
Hickory	*Carya* Nutt.				X					
Hickory, shellbark	*Carya laciniosa* (Michx. f.) Loud.				X					
Hickory, pignut	*Carya glabra* (Mill.) Sweet				X					
Hickory, shagbark	*Carya ovata* (Mill.) K. Koch				X					
Maple, red	*Acer rubrum* L.		X			X	X	X		
Maple, sugar	*Acer saccharum* Marsh.	X	X		X		X			
Oak	*Quercus* L.			X	X					
Oak, black	*Quercus velutina* Lam.			X	X					
Oak, blackjack	*Quercus marilandica* Muenchh.			X						
Oak, bur	*Quercus macrocarpa* Michx.			X	X	X				
Oak, chestnut	*Quercus prinus* L.			X	X					
Oak, chinkapin	*Quercus muehlenbergii* Engelm.				X	X				
Oak, northern red	*Quercus rubra* L.	X	X		X		X	X		
Oak, post	*Quercus stellata* Wangenh.			X						
Oak, Shumard	*Quercus shumardii* Buckl.				X					
Oak, white	*Quercus alba* L.			X	X	X	X			
Pine	*Pinus* L.							X		
Pine, jack	*Pinus banksiana* Lamb.							X		X
Pine, red	*Pinus resinosa* Ait.		X				X	X		
Pine, eastern white	*Pinus strobus* L.		X				X	X		
Spruce, red	*Picea rubens* Sarg.		X				X	X	X	
Spruce, white	*Picea glauca* (Moench) Voss							X	X	X
Yellow-poplar	*Liriodendron tulipifera* L.	X			X					
White-cedar, northern	*Thuja occidentalis* L.		X				X	X		

Table 5.—*Scientific and common names of trees included in the attribute tables. Names follow Little (1979).*

Scientific Names	Common Names
Abies balsamea (L.) Miller	Fir, balsam
Abies fraseri (Pursh) Poir.	Fir, fraser
Acer L.	Maple
Acer rubrum L.	Maple, red
Acer saccharum Marsh.	Maple, sugar
Betula alleghaniensis Britton	Birch, yellow
Betula papyrifera Marsh.	Birch, paper
Carya glabra (Mill.) Sweet	Hickory, pignut
Carya laciniosa (Michx. f.) Loud.	Hickory, shellbark
Carya ovata (Mill.) K. Koch	Hickory, shagbark
Fagus grandifolia Ehrh.	Beech, American
Fraxinus americana L.	Ash, white
Fraxinus nigra Marsh.	Ash, black
Liriodendron tulipifera L.	Yellow-poplar
Magnolia acuminata L.	Cucumbertree
Nyssa sylvatica Marsh.	Blackgum or black tupelo
Picea glauca (Moench) Voss	Spruce, white
Picea rubens Sarg.	Spruce, red
Pinus banksiana Lamb.	Pine, jack
Pinus resinosa Ait.	Pine, red
Pinus strobus L.	Pine, white
Populus L.	Aspen
Populus grandidentata Michx.	Aspen, bigtooth
Prunus serotina Ehrh.	Cherry, black
Quercus L.	Oak
Quercus alba L.	Oak, white
Quercus macrocarpa Michx.	Oak, bur
Quercus marilandica Muenchh.	Oak, blackjack
Quercus muehlenbergii Engelm.	Oak, chinkapin
Quercus prinus L.	Oak, chestnut
Quercus rubra L.	Oak, northern red
Quercus shumardii Buckl.	Oak, Shumard
Quercus stellata Wangenh.	Oak, post
Quercus velutina Lam.	Oak, black
Thuja occidentalis L.	White-cedar, northern
Tilia americana L.	Basswood, American
Tsuga canadensis (L.) Carr.	Hemlock, eastern
Ulmus L.	Elm
Ulmus americana L.	Elm, American

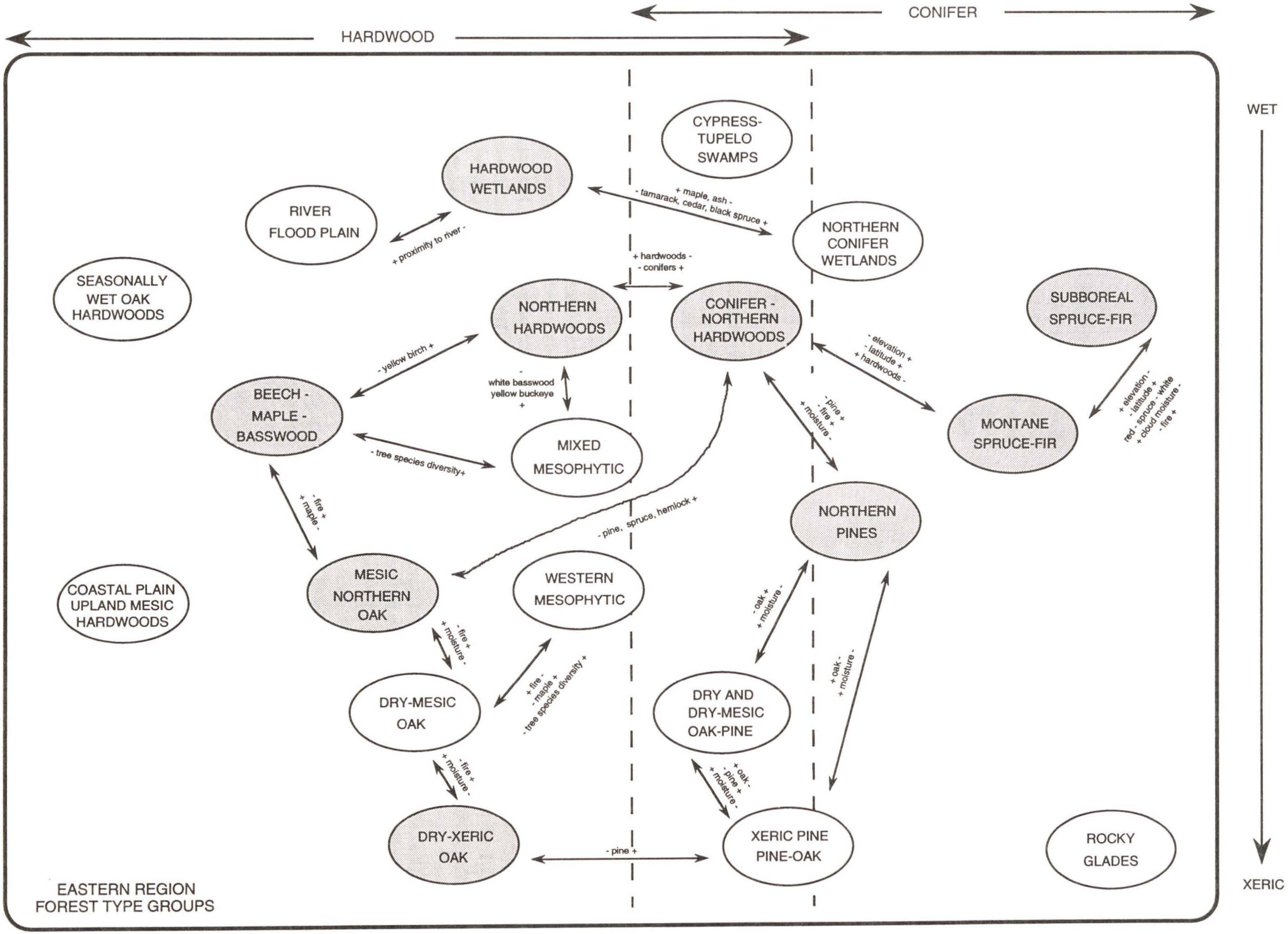
CONIFER
HARDWOOD
WET
XERIC
CYPRESS-TUPELO SWAMPS
HARDWOOD WETLANDS
RIVER FLOOD PLAIN
+ proximity to river -
+ maple, ash -
- tamarack, cedar, black spruce +
NORTHERN CONIFER WETLANDS
SEASONALLY WET OAK HARDWOODS
+ hardwoods -
- conifers +
NORTHERN HARDWOODS
CONIFER - NORTHERN HARDWOODS
SUBBOREAL SPRUCE-FIR
- yellow birch +
- white basswood yellow buckeye +
- elevation +
- latitude +
+ hardwoods -
BEECH - MAPLE - BASSWOOD
- pine +
- fire +
+ moisture -
MONTANE SPRUCE-FIR
+ elevation -
- latitude +
red - spruce - white
+ cloud moisture -
- fire +
- tree species diversity+
MIXED MESOPHYTIC
- fire +
+ maple -
- pine, spruce, hemlock +
NORTHERN PINES
MESIC NORTHERN OAK
WESTERN MESOPHYTIC
COASTAL PLAIN UPLAND MESIC HARDWOODS
- fire +
+ moisture -
- oak +
+ moisture -
+ fire -
- maple +
- tree species diversity +
+ oak -
+ moisture -
DRY-MESIC OAK
DRY AND DRY-MESIC OAK-PINE
- fire +
+ moisture -
+ oak -
- pine +
+ moisture -
DRY-XERIC OAK
- pine +
XERIC PINE PINE-OAK
ROCKY GLADES
EASTERN REGION FOREST TYPE GROUPS

Figure 3.—*Approximate location of old-growth forest type groups along compositional and moisture gradients. Shaded type groups are included in this publication.*

Some of the example stands are referenced in the attribute tables, but we obtained some examples from other citations as listed, and data bases from The Nature Conservancy or State Heritage programs. In general, Davis (1993) is an excellent source for lists of old-growth stands.

An asterisk beside the name of a stand means that the area is known to include more than one forest type group and will appear on lists for those type groups as well. For example, Sylvania Wilderness Area is listed as an example of old growth for northern pines, northern hardwoods, and conifer-northern hardwoods.

Not all stands listed as examples have been studied to document age or structural characteristics. Therefore, these sites are not necessarily included in the location maps and described in the attribute tables.

FOR ADDITIONAL INFORMATION

References cited in the text, figures, and tables are included in the References Cited section. However, additional references may pertain to the forest type group, but the information in the study or paper was not applicable to forest stand structural attributes. These references are listed in Appendix C arranged by forest type group. For example, if a reference did not describe density or basal area of trees, but did sample herbaceous species in an old-growth area of this forest type group, this reference is listed in Appendix C.

Appendix D lists references that were received too late to be incorporated into the figures and tables, but do provide data on old-growth attributes.

GUIDE TO FIGURES (MAPS OF STUDY SITES) AND TABLES

For each forest type group, there are: **FIGURE** (MAP OF STUDY SITES), nine **ATTRIBUTE TABLES** (location, size and elevation of study sites; stand selection criteria and stand composition; methods; density of live trees; basal area of live trees; average and maximum tree age; maximum tree diameter and average tree height; density and basal area of snags; density, basal area, and volume of logs, and total volume of coarse woody debris), and a **SUMMARY TABLE.**

FIGURE (MAP OF STUDY SITES)

Maps

The map for each forest type group shows the general location of studies providing stand structure information. A county on the map is shaded if at least one study occurred in it. Numbers on the map correspond to the cited reference listed under Map Key in the associated figure caption (see Map Key below). For study sites located in Canada, the approximate location is indicated by a shaded block. These blocks were plotted from latitude and longitude information provided by the authors of the cited study.

Figure Captions

The figure captions include the following information:

Map Key.—The references (Source/Date) together with relevant attribute data for each forest type group are listed alphabetically by author and assigned a number. The number is referred to as a Map Key because the number is used on the map to show the location of study sites. The number appears in the counties (or general location in the case of Canadian sites) where the research study or inventory took place.

The Map Key number also identifies the Source/Date of a row entry in all attribute tables for a particular forest type group. The same number identifies this source in all nine attribute tables within each forest type group. Note that each forest type group has its own unique set of sources listed alphabetically and numbered.

A Map Key number is also found in the summary table in the column headed "references", if the study included data for the listed attribute.

Source/Date.—Many of the sources of information are papers published in journals. Other sources include agency reports and notes, theses and dissertations, unpublished literature, and books. Each Source/Date is listed as a full citation in the References Cited section. For ease of communication, the sources of information have been listed alphabetically, and as previously mentioned, referenced by Map Key number within a forest type group.

A source may be associated with more than one forest type group. For example, Hough and Forbes (1943) provide data for both northern hardwoods and conifer-northern hardwoods. Sometimes, a study site contains more than one forest type group. In other cases, it was not clear to us into which forest type group a study site best fit.

State or Province.—For study sites within the United States, we list the State or States in which the studies took place. For Canadian study sites, the Canadian province (Quebec or Ontario) is given.

County or Latitude/Longitude.—Counties are listed in alphabetical order by State. Not all sources provided county information. We used contextual clues (mention of nearest town, maps included in the paper), or personal communication with the author to obtain this information. If we were not certain about the county information, the county name is indicated with an asterisk. In a few cases, several counties were included in a study, but we could not determine which ones they were. Consequently the entry is a description of a region (*e.g.*, central states, northern Minnesota).

For Canadian provinces, latitude and longitude are given. Latitude and longitude were either read directly from the source or estimated from information or maps provided by the source.

ATTRIBUTE TABLES

All Attribute Tables

There are nine attribute tables for each forest type group. Each table shares the first three columns: **Map Key**, **Source/Date**, and **Stand**, which identify the source of information for that entry (row) in each of the nine tables. To better locate information that pertains to the entry (same Map Key, Source/Date, and Stand) within the nine separate tables, the same number of rows of information have been placed on each page. Thus the row of interest will be in the same relative location on each of the nine tables pertaining to the same forest type group.

Map Key.—See Figure (Map of Study Sites) section on previous page.

Source/Date.—See Figure (Map of Study Sites) section on previous page.

Stand.—Most often, this is the name of the study site as described in the source document. In many cases, more than one site was studied. If information was available for each site, then each site or stand was given a separate row entry in the tables, even though the sites shared the source/date and hence Map Key number. However, sometimes the source author(s) studied more than one site but presented the information as data summarized or averaged for the group of sites. If the source/author(s) did not provide a name for the set of sites, a site name or descriptor was created (*e.g.*, 5 stands in New Hampshire; 28 stands in Michigan's Upper Peninsula; Brule River Basin). Sometimes we included qualifiers to indicate what specific composition or elevation of a site was sampled or studied (*e.g.*, Big Reed Pond—red spruce-fir; Great Smoky Mountains— <1830 m).

When the source author(s) provided information separately for several stands and also provided a summary or average for all the stands, a summary row for the study was included first, followed by the individual row-by-row entries for each stand. An example of this is found in Hale (1996) (Map Key 13 for beech-maple-basswood forests). The first row of the Map Key 13 entry is "11 forests in Minnesota", which is then followed by individual entries for all 11 forests (Bello, Big Island, Dinosaur Island, etc.). In the case of beech-maple-basswood, because of the richness of data sources for this forest type, in general, sources were were included in the tables only if they used 10 cm d.b.h. as the minimum size for measuring and tallying trees. However, recent sources that had sampled snags and logs were included, even if the minimum diameter for tallying trees was not 10 cm.

Location, Size, and Elevation of Study Sites

State or Province.—For each stand entry (each row in the table), location information is given. See Figure (Map of Study Sites) in previous column.

County or Latitude/Longitude.—For each stand entry (each row in the table), location information is given. See Figure (Map of Study Sites) on previous page.

Size.—Size refers to the size of the study area. However, study area was sometimes difficult to determine or was unspecified. If available from the source, the size listed is the size of the area represented by the sampling, sometimes corresponding to one stand (*e.g.*, Five Ponds Wilderness—Plot 5; Salsbury Cove; Hunt Hill) and sometimes to several stands in a locality (*e.g.*, Mianus Gorge). However, in some cases, the size is that of a larger area in which the study occurred (Menominee County, Porcupine Mountains, Brule River basin, Bark Lake). In any case, the size is not a listing of the total area occupied by sample plots (see Methods instead). Size is reported in hectares, rounded to the nearest hectare for stands at least 5 ha in size, and to the nearest 0.1 ha for smaller stands.

Elevation.—Elevation of the study site or area is reported in meters, and converted to meters from feet, if needed. Sometimes the source gave elevation in feet, and appeared to give rounded values (*e.g.*, elevations rounded to the nearest 5 or 10'). However, after conversion of feet to meters, the rounded aspect of the original was no long apparent (*e.g.*, 443-528 m). For some sites, an elevation range is provided. The elevation of some study sites was unspecified by the source author(s).

Criteria for Stand Selection and Stand Composition

Information about selection criteria, site disturbance history, and species composition are separated in this column by semicolons. Reported in this column are brief "answers" to the following questions:

> Why did the source author(s) consider this stand or area for study as old growth, *i.e.*, what terms did the source author(s) use to describe it as old growth? Here we find words or phrases such as:
>
> virgin, near-virgin, remnant, near-original, little-disturbed, relatively undisturbed, best remaining old growth, representative of original forest, relatively few signs of anthropogenic disturbance, minimal human-caused disturbance, no cutting, reserve, no signs of cutting, uncut, never logged, no cutting known, unlogged, uncut and undisturbed, considered old growth, virgin timber, old, mature, climatic climax, primeval, specific percent crown in large trees, relatively pristine appearance, trees of large diameters.
>
> What does the source author(s) report about the old-growth area's disturbance history? Modifications of a site by recent or not so recent grazing, logging, salvage, fires, fire suppression, tornados, ice storms, or hurricanes will affect the structural characteristics of a stand. Structural attribute data presented elsewhere in the tables (tree density and basal area, tree age and size, and structure of coarse woody debris) should be interpreted in light of any site modifications presented in this column and their possible impacts on stand structure. Here we find words or phrases such as:
>
> some logging, some recreational impacts, minimal fuelwood cutting, light grazing in the past, selectively cut in distant past, little disturbance in last 60 to 70 years, old sugar bush, cut only sporadically before 1920, intermittent grazing, survived hurricane undisturbed, salvage white pine cut in 1911, burned in the past, some hurricane damage, scattered stumps, lumbering in late 1800's, undisturbed by adelgid, high-graded in late 1800's, no evidence of past fire, some areas logged ca. 1888.
>
> What is the species composition of the stand?
>
> The species composition is reported on a percentage basis by basal area when available, otherwise by density. Footnotes are common here to further clarify how the species composition was presented by the source authors, or computed from data in the cited reference.

Common names of trees are used (Little 1979) but sometimes abbreviated (*e.g.*, basswood for American basswood).

Conifer Type.—Included in the Criteria for Stand Selection and Stand Composition table for conifer-northern hardwood forests is a column that indicates which conifer species (eastern hemlock, red spruce, or eastern white pine) is dominant at the site. Frequently, one conifer is dominant. However, many sites have some two-species combination, and all two-species combinations occur on at least one site (white pine-hemlock, hemlock-white pine, white pine-red spruce, red spruce-white pine, hemlock-red spruce, red spruce-hemlock). The order in which the species are listed reflects the relative dominance of the species. All three species occur on some sites. Northern white-cedar is present at several sites.

Species of Pine.—Included in the Criteria for Stand Selection and Species Composition table for northern pine forests is a separate column that indicates which species of pine (white, red, or jack) occur at the site. Many sites contain two or three species. Red pine and white pine frequently co-occur, with either species dominant. All three species can occur together, with any of the three species dominant. A gradient of stands seems to occur, with composition probably reflecting patterns of soil moisture or fertility. Because the size and longevity of red and white pines differ greatly from jack pine, it is important to know what species are dominant on a site when interpreting its stand attribute data. A jack pine stand would never attain the huge basal areas encountered in an old-growth white pine grove. Conversely, basal area of a jack pine old-growth stand should not be interpreted as an adequate minimum standard for an eastern white pine old-growth stand.

Sampling Methods

We condensed to one line the methods that the source author(s) used to conduct the study. Consequently, not much detail is given; we chose to emphasize the number, size, shape, and arrangement of plots or transects used to sample attributes of trees in the area. This information gives some indication of sampling intensity and data quality (*i.e.*, whether the sample is representative of the stand). Some sampling was based on round, rectangular, or square plots, or belt or strip transects. Plots may have been located randomly, randomly with stratification, or systematically. Information about total area sampled can be calculated from the numbers and sizes of plots. Plot dimensions or areas have been converted to meters or hectares, respectively (see conversion table inside front cover) and rounded as appropriate.

Plotless methods included prism "plots", point-quarter sampling, walk-through inventories, casual observations, extracting increment cores, examination of stumps, and use of records from General Land Office surveys before European settlement. Prism plot factors have not been converted to metric equivalents. In a few cases, the source author(s) did not provide enough information to describe what methods were used.

Sampling of herbaceous vegetation, saplings and seedlings, soils, and other stand components may have been reported in the source document. However, we did not include these in the Sampling Methods, as the focus here is on tree- and stand-level attributes.

Possible Confusion With These Types.—An additional column is included in the Methods for two forest type groups: dry and xeric oaks (Table 29), and mesic and wet-mesic northern oaks (Table 39). If the composition of a particular site is a borderline case between two type groups, that is mentioned in this column of the Methods. For dry and xeric oaks (Table 29), the confusion exists in separating these forests and woodlands from dry-mesic ones. For mesic and wet-mesic northern oaks (Table 39), the confusion arises as to whether the oaks have succeeded to mixed mesophytic forests, or might better be classified as slightly drier (dry-mesic) forests.

Density and Basal Area of Live Trees

We provide information about density and basal area of live trees where available. Many of the references with data on structural attributes included data on live tree density (41-83 percent of references, depending on the forest type group) and basal area (48-70 percent of references, depending on the forest type group) (Table 6).

Table 6.—*Number and percentage of references with data on old-growth attributes.*

Forest Type Group	Total Number of References with Data	Percentage of References (%)						
		---------------Live Trees---------------				---------Dead Trees---------		
		Density	Basal Area	Tree Age	Tree Diameter	Snags	Logs	Canopy Gaps
Hardwoods								
Beech-maple-basswood	43	77	70	12	58	23	7	12
Northern hardwoods	46	41	48	46	59	15	4	4
Oaks, dry and xeric	11	72	64	18	55	27	19	0
Oaks, mesic and wet-mesic northern	59	71	51	31	59	27	27	8
Wetlands, hardwood	6	83	67	33	33	17	17	0
Mixed Conifers and Hardwoods								
Conifer-northern hardwoods	59	56	59	36	58	29	17	8
Conifers								
Pines, northern	33	58	55	73	55	21	12	3
Spruce-fir, montane and allied	29	59	55	62	62	21	3	7
Spruce-fir, subboreal	6	67	33	50	50	0	0	0
Total References[1]	292							

[1] Some references are counted more than once if they included data for more than one forest type group.

Stand densities and basal areas of trees 10 cm and larger, 50 cm and larger, and 70 cm and larger in d.b.h. are reported in separate columns. The ≥10 cm diameter is the most common cutoff between saplings and trees, as well as the most common size reported. In a few cases (noted at the end of the table), the value reported is not the stand density or basal area, but rather the density of one species or a few species dominants (*e.g.*, black spruce and jack pine, see Map Key 6, Ohmann and Ream (1971b), Table 90). In some cases, density values were inferred from size-frequency tables or graphs.

The ≥50 cm and ≥70 cm columns reflect the presence of large trees that would be found in old stands of some forest types but not in young stands. References reported in this column may also have data for the ≥10 cm column.

If diameter cutoffs other than ≥10, ≥50 or ≥70 cm were used, the density or basal area is reported in the ≥X column and the minimum diameter is reported in the column labelled "Min Diam X". Other size cutoffs reported included: 2.0, 2.5, 7.6, 12.7, 20, 25, 35, and 40. For conifer-northern hardwood forests, additional columns headed "Density ≥Y cm", "Basal Area ≥Y", and "Min Diam Y" were included to report densities and basal areas of live trees of sizes other than those reported in other columns (Tables 60, 61).

A blank in any column indicates that no information was available; a zero indicates that the stand contained no trees of this size.

The diameter minimum chosen by the source author greatly influences tree density or basal area reported for a stand or site. Comparisons among sites can be useful only if the values were obtained using the same size trees.

Average and Maximum Tree Age by Species

We provide information about average or maximum tree age where available. Numbers of references with data on structural attributes that included data on tree age varied among forest type group (12-73 percent of references depending on forest type group) (Table 6).

Average Tree Age.—This attribute is reported for at least one site in all forest type groups except subboreal spruce-fir forests. Information about how many trees were aged is given in the notes.

Maximum Tree Age.—This attribute is reported for all forest type groups except beech-maple-basswood. Many ages are estimates, based on ring counts from increment cores. The tree age is greater than reported if the corer did not reach the tree center, the center was rotten, or the core was taken above ground level. Such ages are followed by a plus sign to indicate that these estimates are conservative. Some researchers were hesitant to age a stand on the basis of a few cores. Cores taken near a study plot may not represent the variation or maximum ages of trees present in the stand.

Maximum Tree Diameter by Species, Average Canopy Height, Canopy Gaps

Information about maximum tree diameter by species and canopy gaps is provided where available. About 50 percent of references with any data on structural attributes included data on maximum tree diameter (33-62 percent of references depending on forest type group) and less than 15 percent for canopy gaps (Table 6).

Maximum Tree Diameter.—This attribute is sometimes qualified by elevation information in the notes. Diameters, reported rounded to the nearest centimeter, were taken at 1.4 meters (diameter at breast height—d.b.h.) unless otherwise noted. A few diameters were measured above the root crown or from stumps.

Average Canopy Height.—Average canopy height, rounded to the nearest meter, is included for beech-maple-basswood (Table 13) and northern pines (Table 73). If the stand had both canopy and supercanopy, or different heights by species, heights are reported separately or qualifying remarks are entered as notes.

Canopy Gaps.—We report the percent of canopy in gaps if available. Sometimes canopy gaps are estimated as the percent canopy cover per unit area, while in other cases they are estimated by recording the length of transect that intersects gaps as a percentage of the total transect. This structural attribute is relevant to closed-canopy forests rather than woodlands or savannas.

Density, Basal Area, and Volume of Snags

Information about standing dead trees (snags) is provided where available. The percentage of references for a forest type group with data pertaining to snags ranged from 0 percent for subboreal spruce-fir to 29 percent for conifer-northern hardwoods (Table 6).

Density of Snags.—A column for density of snags is included for all forest type groups, although frequently the column is blank due to lack of information.

Basal Area of Snags.—Columns for snag basal area are included for all forest type groups except beech-maple-basswood.

Volume of Snags.—A column for volume of snags is included for conifer-northern hardwoods, beech-maple-basswood, hardwood wetlands, mesic and wet-mesic oak, and northern pines.

Minimum Diameter.—Listed in this column is the minimum size for tallying snags. If the minimum diameter was not the same for density and volume, this is noted. Minimum criteria for tallying snags other than diameter (*i.e.*, snag height) may differ widely among studies. We noted these minima wherever possible. The density, basal area, and volume of snags would be much greater for all snags >1 m tall than for all snags >3 m tall.

Density and Volume of Logs, and Total Volume of Coarse Woody Debris

Information about fallen dead trees (logs) is provided where available. The percentage of references referring to logs for a forest type group ranged from 0 percent for subboreal spruce-fir, dry and xeric oaks, and hardwood wetlands, to 27 percent for mesic and wet-mesic northern oaks (Table 6).

Density of Logs.—A column for density of logs is included for all forest type groups.

Volume of Logs.—A column for volume of logs is included for all forest type groups.

Minimum Diameter.—We list the minimum diameter for tallying logs. If the minimum diameter was not the same for density and for volume, this is noted.

Total Volume of Coarse Woody Debris.—Total volume of logs and snags is given for conifer-northern hardwoods, beech-maple-basswood, and northern pines. Minimum diameter for snags and logs is the same and listed in the minimum diameter column unless otherwise noted.

SUMMARY TABLES

These tables summarize information presented in the nine tables for a given forest type group arranged by ATTRIBUTE, RANGE OF VALUES, and REFERENCES (MAP KEY).

Attributes

The stand structural attributes summarized are live tree density, live tree basal area, tree or stand age (by species), maximum tree diameter (by species), average tree height (for some forest type groups), snag density, snag basal area, snag volume (for some forest type groups), log density, log volume, and total volume of coarse woody debris (logs and snags) (for some forest type groups).

Different studies used different minimum diameters for trees, snags, and logs. For example, some researchers reported values for northern pine forests for trees ≥2.5 cm, ≥10 cm, and ≥25 cm. However, nine references used some other minimum size (references 2, 3, 8, 16, 19, 20, 25, 30, 33—Table 76).

Density, Basal Area, and Volume.—Density, basal area, and volume for live and dead trees are reported by size of trees. In some cases, these were minimum sizes specified in the sampling methods for the study. Minimum sizes for trees were frequently 10 cm, but 2 cm, 2.5 cm, 4 cm, or 20 cm minima were also encountered. In some cases, larger sizes were established to find out how many "big" trees were present in a stand. Information was taken directly from the cited reference or indirectly from graphs or size frequency tables in the reference to correspond to these minimum size classes (*e.g.*, ≥50 cm, ≥70 cm). For example, for northern hardwoods, the summary table reports values for density of live trees ≥2.5 cm, ≥10 cm, ≥35 cm, ≥50 cm, and ≥70 cm. Despite this variety of minimum size classes, some studies used other minimums. These are reported collectively as "Not as specified above". When prism plots were used (based on English prism factors), minimum sizes are not reported here.

Tree Age and Diameter.—Average or maximum tree age and maximum tree diameter are summarized by species. Clearly, the maximum size that could be attained by a bur oak versus a red oak in a mesic oak forest, or by jack pine versus eastern white pine in a northern pine forest would be different. Age and diameter are reported for major species likely to be encountered in each forest type group. Common species for which data are included in these attribute tables are listed in Table 4 (by forest type group). Typically, tree ages are based on overstory dominants. Tree ages need to be interpreted with caution. In some cases, only a few cores were taken. In others, the trees may have been sampled in such a way that the ages are not representative of the stand. Similarly, the largest reported diameter may be the largest diameter sampled rather than the largest in the stand. To complicate things further, the largest or oldest tree may be one of only a few of this size or age, misrepresenting the rest of the stand as older than it is. Given the size of the largest tree or the age of the oldest, questions still need to be asked: How does the largest or oldest compare to the stand average? What is the size frequency or age frequency distribution for the stand? How do these distributions differ by species?

Average Canopy Height.—Average canopy height by species is summarized for beech-maple-basswood (Table 16) and northern pines (Table 76).

Snags and Logs.—We summarize data that are based on different definitions used by source authors for snags and logs (*e.g.*, minimum snag height, whether stumps are included, decay criteria). The summary values should be interpreted with this in mind. Some studies pooled logs, snags, and stumps together as dead trees. These values are included in the attribute tables with notes, but were not incorporated into the summary tables. Total volume of coarse woody debris is reported for beech-maple-basswood, conifer-northern hardwoods, and northern pines.

Range of Values

Variation Encountered.—The range of values summarizes the attribute tables for the forest type group. The range of values represents differences in stand age, tree species composition, degree of disturbance (how recent? how extensive?), and influences of elevation, topography, slope, aspect, and soils.

The summary table does not give the full range of attributes found in extant examples of old growth for each forest type, as not all attributes were measured in each study (Table 6), and those forests that were studied many not be truly representative examples. Many more studies gathered information about live tree density and basal area than about snags or logs (Table 6). Few studies gathered information about canopy gaps (Table 6).

The values reported in the attribute tables result from a variety of sampling methods. Some studies report the results from intensive sampling of many plots in many stands. Other studies report the results from one plot in one location. So, it is not meaningful to report a mean value for any attribute.

Incomplete Information.—If the attribute table reports density or basal area for several dominant tree species but not the entire stand, that density or basal area is not reported as a maximum or minimum in the summary table.

Not Minimum Criteria.—The range of values represents some of the natural variation that occurs within forests of this group. However, it does not constitute critical values or minimums that distinguish mature forest from old growth. The studies that provide data for the attribute tables summarized here took place in what the source authors considered old growth. However, the source authors may have been conducting the study for some reason other than to determine how old-growth structure differs from that of mature forests. In many cases, the stands were chosen by source authors because the stands or areas were considered to be old growth without question, rather than selecting stands at the developmental stage where true old growth begins (Oliver and Larson 1996). Values for attributes in such forests may represent well-developed old-growthness, rather than the transition between mature forests and old growth. Reviewing the CRITERIA FOR STAND SELECTION AND STAND COMPOSITION in the attribute tables will inform the reader of the range of forests from which the range of values comes.

References (Map Key)

Following each attribute are the Map Key numbers corresponding to all of the cited references that provide data about that attribute. The references that report the maximum and minimum values are included in the Map Key list, but are not identified as such. Scanning the column in the attribute tables for the attribute in question will identify which studies contributed the maximum and minimum values. Questions to ask in relation to these maximum and minimum values are: Why are these values so high? low? Are the values high or low because of greater degree of old-growthness? disturbance history? species composition?

GUIDE FOR LOCATING INFORMATION

Following are suggestions on how to access old-growth information in this publication.

INFORMATION RELATED TO PLACE

To focus on a geographic area of interest, whether a region, State, national forest, or single county, refer to the nine type group maps (Figs. 4-12). Map Key numbers identify studies that took place in that target geographic area. The Map Key leads to the pertinent information in the tables that correspond to that map or forest type group.

For example: Suppose you are interested in results of studies conducted in old-growth forests in northwestern Pennsylvania. You glance at all nine maps, scanning northwestern Pennsylvania for counties that contain Map Key numbers. No studies were conducted in Pennsylvania forests that pertain to hardwood wetlands, xeric oak, mesic oak, beech-maple-basswood, or subboreal or montane spruce-fir. However, several studies are documented for northern hardwood forests (Map Key numbers (13, 15, 27), conifer-northern hardwood (23, 24, 30, 32, 35, 36, 39, 44, 51, 58), and northern pine (12, 16, 21).

NEAREST RELEVANT INFORMATION FOR A FOREST TYPE GROUP

To find stand structural information for a particular forest type group that is most relevant for a particular geographical area, check the map showing the study sites for the appropriate forest type group for studies (via Map Key numbers) located in the area of interest. If few data exist for the type group, no study may have occurred near the area of interest. In that case, by scanning the map, you can identify any studies that occurred near the area of interest. Such studies may be helpful if the site is not too different in species composition, soils, geography, or elevation to be used as a reference study for the area of interest.

For example: You would like to know which studies on northern hardwood forests are most relevant to your location in northwestern Pennsylvania. Scanning the map for northern hardwood forests (Fig. 5), you see that the citations to look up in the northern hardwood tables are: Goodlett (1954) (Map Key 13, in Potter County), Hough and Forbes (1943) (15, in McKean and Warren Counties), and Lutz (1930a) (27, in Warren County).

For example: You would like to know about old-growth characteristics of hardwood wetlands especially in elm-ash-maple swamps in northern Wisconsin. The map of hardwood wetlands (Fig. 8) shows that no known studies examined such swamps in Wisconsin. The nearest studies were Hale's (1996) work in Pine or Carlton Counties in Minnesota (Map Key 3), or Boerner and Cho's (1987) study in Fulton County, Ohio (Map Key 1). By consulting Table 48, you can determine that the Pine County stand (Hay Creek) was 33 percent black ash and the Carlton County stand (Jay Cooke) was 30 percent black ash. Because the composition of these stands may be similar to that of the elm-ash-maple swamps you are interested in, stand structure data from both sites may provide some useful information, if interpreted with caution.

INFORMATION BY TREE SPECIES

To find out the maximum diameter or age of a particular tree species in an old-growth condition, there are several avenues to follow. Table 1 provides an overview of SAF cover types included in each forest type group. Tables 2 and 3 provide crosswalks from SAF and CDS cover types to the relevant forest type group(s). This information is repeated in the composition portion of the text for each forest type group. It may be particularly helpful to consult Table 4, which lists the common names of those tree species included in the attribute tables for tree age, diameter, and canopy height and their associated forest type groups. Some tree species occur in several forest type groups. Information on tree age and tree diameter can be obtained for these species from the attribute and summary tables for forest type groups identified from Table 4.

For example: Suppose you would like to know more about the characteristics of balsam fir in old-growth stands. From Table 2 you find that balsam fir (SAF 5) corresponds to both montane spruce-fir and subboreal spruce-fir forest type groups. Note that Table 1 also lists balsam fir under both of these forest type groups. Table 82 and 83 (montane spruce-fir) and Tables 92 and 93 (subboreal spruce-fir) provide information about maximum age and diameter of balsam fir, which is summarized in Table 86 (montane spruce-fir) and Table 96 (subboreal spruce-fir).

INFORMATION BY SPECIFIC SORTING FACTOR

Within a given forest type group, certain attributes can be selected for sorting out relevant sites from all the studies. Sorting factors could be elevation, size of stand, species composition, size limit on tree measurements, tree age, or tree diameter. The column that includes the sorting factor chosen (*e.g.*, elevation) can be scanned to identify stands that have the value of the attribute of interest. Once the Map Key number with Source/Date and Stand Name has been noted for those studies that meet the screening test, the tables that give additional information for that forest type group can be consulted, zeroing in on the Map Key numbers (specific rows) previously selected.

For example: Suppose you are interested in montane or allied spruce-fir forests that occur 800-900 m elevation. To locate any studies conducted in stands at this elevation, turn to Table 77 (location, size, and elevation for montane spruce-fir forests) and search the elevation column for studies (rows) with entries of 800-900 m. After noting the Map Key numbers, Source/Date, and Stand Name that correspond to your target elevational range, (*e.g.*, 3 (Carbonneau (1986a), Gibbs Brook, Nancy Brook), 5 (Cogbill (1996), Basin Ponds, Bernard Mountain), 8 (Fitzgerald and Raynal (1991), Whiteface Mountain), etc.), you can look in the other montane spruce-fir tables at the rows that you have now identified as being of the suitable elevation.

INFORMATION BY FOREST TYPE GROUPS

▲ ***Sylvania Wilderness**, Ottawa National Forest, Michigan. Small to large diameter classes are present in this old-growth hemlock-northern hardwood stand near Helen Lake. Tree ages upwards of 350 years were recorded. See also Tyrrell and Crow (1994).*

BEECH-MAPLE-BASSWOOD FORESTS

COMMUNITY COMPOSITION

Forest Cover Types

The following Society of American Foresters (SAF) forest cover types (Eyre 1980) are included in the beech-maple-basswood forest type group:

26 - sugar maple-basswood
27 - sugar maple
60 - beech-sugar maple

The following Combined Data Systems (CDS) forest cover types for the USDA Forest Service Eastern Region (USDA 1974) are included in the beech-maple-basswood forest type group:

82 - sugar maple/basswood
85 - sugar maple
86 - beech

Species Composition

Sugar maple (*Acer saccharum* Marsh.) forms associations with American basswood (*Tilia americana* L.) in the Upper Great Lakes Region (*e.g.*, "Big Woods" of Minnesota) and with American beech (*Fagus grandifolia* Ehrh.) further south and east. The western margin of beech's range in eastern Wisconsin demarcates the transition between basswood and beech as primary associates of sugar maple (see Ward 1958). Trees common to this forest type include red maple (*Acer rubrum* L.), white ash (*Fraxinus americana* L.), yellow-poplar (*Liriodendron tulipifera* L.), northern red oak (*Quercus rubra* L.), eastern white pine (*Pinus strobus* L.), and eastern hemlock (*Tsuga canadensis* [L.] Carr.). See appendix in Lindsey and Escobar (1976) for a complete listing of trees, shrubs, herbaceous plants, and animals occurring in this forest type.

PHYSICAL CONTEXT

Physiographic Provinces

Beech-maple-basswood forests occur in the following physiographic provinces (after Fenneman 1938):

Coastal Plain	(Embayed section)
Piedmont	(Northern portions of both sections)
Ridge and Valley	(Middle section)
Appalachian Plateaus	(Alleghany Mountain, Unglaciated and Glaciated Alleghany Plateau sections)
New England	(Upland section)
Central Lowland	(Great Lake, Till Plains, Driftless, Western Young Drift, and Dissected Till Plains sections)

◀ ***Colonial Point**, in the northern part of the Lower Peninsula of Michigan, includes large red oaks. Sugar maple is common in the understory. Photo 5/92 by Lucy Tyrrell.*

▲ ***Hunt Hill**, part of a State Natural Area in Washburn County, Wisconsin, is located west of the range of beech. The composition of the 120+ year forest at Hunt Hill includes red oak, white oak, and red maple, in addition to sugar maple and basswood. See Eggler (1938) and Tyrrell (1988d). Photo 7/89 by Lucy Tyrrell.*

Ecological Units

Beech-maple-basswood forests occur in several divisions and provinces (see Keys *et al.* 1995):

- 200 Humid Temperate Domain
- 210 Warm Continental Division
- 212 Laurentian Mixed Forest Province
- 220 Hot Continental Division
- 221 Eastern Broadleaf Forest (Oceanic) Province
- 222 Eastern Broadleaf Forest (Continental) Province
- 250 Prairie Division
- 251 Prairie Parkland (Temperate) Province

Geographic Distribution

Beech-maple-basswood forests are located generally in the northern tier of eastern states extending into southern Canada. This forest type extends from Minnesota to southern New England. Its southern boundary roughly corresponds to the southern limit of past glaciation.

Soils

Beech-maple-basswood forests typically grow on mesic, upland sites and prefer circumneutral, well- to moderately well-drained loams and silt loams. Due to their inherent site productivity, many beech-maple-basswood forests have been converted to farmland.

DISTURBANCE

Canopy disturbances are frequent but of low intensity, often forming single- or small, multiple-tree gaps (Runkle 1990). Thus, gap-phase regeneration occurs in this forest type (Bray 1956), possibly with a pattern in which sugar maple establishes under beech and beech establishes under sugar maple, thus replacing each other (reciprocal replacement) (Fox 1977, Woods 1979; but see Poulson and Platt 1996). This forest type is particularly sensitive to fire, and its presettlement distribution may have been restricted to areas that experienced little or no fire (Grimm 1984). The near elimination of fire in the present-day landscape may allow this forest type to expand. Indeed, the principal tree species of this forest type already dominate the understories of many fire-dependent communities in the region (oak-dominated forests in particular).

RELATION TO OTHER FOREST TYPES

Throughout much of its range, this forest type grades into northern hardwoods and conifer-northern hardwoods to the north and mesophytic forests to the south. It is distinguished from northern hardwoods by occurring only on warmer, low elevation sites where yellow birch (*Betula alleghaniensis* Britton) is generally absent (*e.g.*, broad valley floors, toe slopes). It differs from conifer-northern hardwoods by having less than 25 percent of its canopy in conifers. It is distinguished from mesophytic forests by having fewer tree species and less

▲ ***Warren Woods** is an old-growth tract of beech and sugar maple in southwestern Michigan. See Cain (1935), Schmelz (1964), Woods (1979), and Rogers (1992). Photo 1989 by Lucy Tyrrell.*

tree diversity, favoring dominance by sugar maple, American beech, and American basswood. Specifically, the importance (*i.e.*, basal area) of maple, beech, and basswood combined is twice or more that of the oak-hickory component (see Lindsey *et al.* 1969, p. 196).

STRUCTURAL CHARACTERISTICS OF OLD-GROWTH STANDS

Information about beech-maple-basswood forests in an old-growth condition is included in Figure 4 and Tables 7 through 16.

SELECTED REPRESENTATIVE OLD-GROWTH STANDS

Indiana

Allee Memorial Woods, Parke Co.
(Jackson 1966, Lindsey and Schmelz 1970, Lindsey *et al.* 1969, Rogers 1982, Schmelz and Lindsey 1970, Williams 1962)

Bendix Woods Nature Preserve, St. Joseph Co.
(Davis 1993, Lindsey and Schmelz 1970, Lindsey *et al.* 1969, Riemenschneider and Blodgett 1983, Rogers 1982, Schmelz and Lindsey 1970)

Caster's Woods, Montgomery Co.
(Lindsey and Schmelz 1970, Lindsey *et al.* 1969, Rogers 1982)

Heron Woods, Big Walnut Natural Area, Putnam Co.
(Davis 1993, Lindsey *et al.* 1969, Lindsey and Schmelz 1970, Rogers 1982, Schmelz and Lindsey 1970)

Hoot Woods, Owen Co.
(Abrell and Jackson 1977; Davis 1993; Jackson and Abrell 1977; Jackson and Allen 1967; Lindsey and Schmelz 1970; Lindsey *et al.* 1969; Petty and Lindsey 1962; Schmelz 1964; Schmelz and Lindsey 1965, 1970; Williamson 1975)

Hultz Woods, Putnam Co.
(Rogers 1982)

Jackson's Woods, Versailles State Park, Ripley Co.
(Jackson and Allen 1969, Lindsey and Schmelz 1970, Lindsey *et al.* 1969, Schmelz and Lindsey 1970)

Kado-Lato Woods, DeKalb Co.
(Lindsey *et al.* 1969, Rogers 1982)

LaPorte Woods, LaPorte Co.
(Lindsey and Schmelz 1970, Lindsey *et al.* 1969, Rogers 1982)

Logansport Woods, Cass Co.
(Lindsey *et al.* 1961, 1969; Lindsey and Schmelz 1970; Rogers 1982; Schmelz 1964; Schmelz and Lindsey 1965, 1970)

Manlove Woods, Fayette Co.
(Davis 1993, Lindsey and Schmelz 1970, Lindsey *et al.* 1969, Rogers 1982, Schmelz and Lindsey 1970)

Meltzer Woods, Shelby Co.
(Davis 1993, Keller 1945, Lindsey and Schmelz 1970, Lindsey *et al.* 1969, Rogers 1982, Schmelz and Lindsey 1970)

Officers' Woods North, Jefferson Co.
(Davis 1993, Lindsey and Schmelz 1970, Lindsey *et al.* 1969, Schmelz and Lindsey 1970)

Ogden Woods, Wabash Co.
(Lindsey *et al.* 1969, Rogers 1982)

Pine Hills Nature Preserve, Montgomery Co.
(Lindsey and Schmelz 1970; Lindsey *et al.* 1969; Schmelz 1964; Schmelz and Lindsey 1965, 1970)

Pioneer Mothers Memorial Forest (Cox Woods), Orange Co.
(Davis 1993; Lindsey and Schmelz 1970; Lindsey *et al.* 1969; Potzger *et al.* 1942; Schmelz 1964; Schmelz and Lindsey 1965, 1970)

Potzger's Woods, Versailles State Park, Ripley Co.
(Jackson and Allen 1969, Lindsey and Schmelz 1970, Lindsey *et al.* 1969, Potzger 1950, Potzger and Chandler 1950, Schmelz and Lindsey 1970, Stearns 1956)

Rocky Hollow, Turkey Run State Park, Parke Co.
(Auten 1933, Davis 1993, Esten 1932, Lindsey and Schmelz 1970, Lindsey *et al.* 1969, Schmelz and Lindsey 1970)

Rosbrugh Woods, Kosciusko Co.
(Lindsey and Schmelz 1970; Lindsey *et al.* 1969; Rogers 1982; Schmelz 1964; Schmelz and Lindsey 1965, 1970)

Rush Woods, Montgomery Co.
(Lindsey and Schmelz 1970, Lindsey *et al.* 1969, Petty and Harwood 1964, Rogers 1982, Schmelz and Lindsey 1970)

Shades State Park, Montgomery Co.
(Auten 1933, Rogers 1982)

Weaver Woods, Fayette Co.
(Lindsey and Schmelz 1970, Lindsey *et al.* 1969, Rogers 1982, Schmelz and Lindsey 1970)

Michigan

Bangham Woods, Jackson Co.
(Rogers 1981, 1982)

First Woods, Berrien Co.
(Rogers 1981, 1982)

Fuller Woods, Van Buren Co.
(Rogers 1981, 1982)

Lyon Woods, Ingham Co.
(Rogers 1981, 1982)

Morgan Woods, Washtenaw Co.
(Rogers 1981, 1982)

Russ (Newton) Woods, Cass Co.
(Lindsey and Escobar 1976; Rogers 1981, 1982)

Toumey Woods, Ingham Co.
(Harlan and White 1967; Lindsey and Escobar 1976; Palik 1988; Palik and Murphy 1990; Rogers 1981, 1982; Schneider 1963)

▲ *Beech and sugar maple dominate the old-growth forest at* ***Hueston Woods State Park*** *in Ohio. See Runkle (1982) and Runkle* et al. *(1984). Photo 4/92 by Lucy Tyrrell.*

Warrens Woods, Berrien Co.
(Auten 1933; Billington 1924; Brewer 1980; Brewer and Merritt 1978; Cain 1935; Dice 1920; Donnelly 1986; Donnelly and Murphy 1987; Fox 1977; Lindsey and Escobar 1976; Lindsey and Schmelz 1970; Peters and Poulson 1994; Poulson and Platt 1989, 1996; Rogers 1981, 1982; Schmelz 1964; Schmelz and Lindsey 1965, 1970; Woods 1979)

Wells State Park, Menominee Co.
(Davis 1993)

Woldumar, Eaton Co.
(Lindsey and Escobar 1976)

Minnesota

Cedar Lake Woods, Rice Co.
(Rogers 1981, 1982)

Diamond Lake Woods, Hennepin Co.
(Bray 1956; Lindsey and Escobar 1976; Rogers 1981, 1982)

Henry Woods, Hennepin Co.
(Rogers 1981, 1982)

Limbeck Woods, Hennepin Co.
(Rogers 1981, 1982)

Minnetonka Woods, Hennepin Co.
(Daubenmire 1936, Lindsey and Escobar 1976, Rogers 1981)

Nerstrand Woods, Rice Co.
(Davis 1993; Rogers 1981, 1982)

Northfield (Rabbit Run) Woods, Rice Co.
(Daubenmire 1936, Lindsey and Escobar 1976)

Ponemah Point, Beltrami Co.
(Buell and Bormann 1955)

Richter Woods, Le Sueur Co.
(Davis 1993; Rogers 1981, 1982)

Taylor Woods, Hennepin Co.
(Rogers 1981, 1982)

Townsend Woods, Rice Co.
(Davis 1993)

Wolsfeld Woods, Hennepin Co.
(Rogers 1981)

Missouri

Douglas Woods, Boone Co.
(Kucera and McDermott 1955)

Schnabel Woods, Boone Co.
(Davis 1993, Kucera and McDermott 1955)

New York

Green Lakes State Park, Onondaga Co.
(Lindsey and Escobar 1976)

Ohio

Ansell's Ledges, Geauga Co.
(Lindsey and Escobar 1976, Pell and Mack 1977)

Blacklick Woods, Fairfield Co.
(Boerner and Brinkman 1996, Fritts 1958, Lindsey and Escobar 1976, Rogers 1982, Sudia 1960)

Bole Forest, Geauga Co.
(Pell and Mack 1977)

Crall Woods, Ashland Co.
(Aughanbaugh 1964, Davis 1993, Lindsey and Escobar 1976, Pell and Mack 1977, Rogers 1982)

Dysart Woods, Belmont Co.
(Davis 1993, Lafer and Wistendahl 1970, Webster and Adams 1973)

Etna Township, Licking Co.
(Christy 1952, DeSelm 1952, Gilbert and Riemenschneider 1980, Laufersweiler 1955)

Firestone Woods, Mahoning Co.
(Pell and Mack 1977)

Fowler Woods, Richland Co.
(Davis 1993, Pell and Mack 1977, Rogers 1982)

Goll Woods, Fulton Co.
(Bain 1940, Boerner and Cho 1987, Cho and Boerner 1991a, Davis 1993, Keiser 1966, Lindsey and Escobar 1976)

Graber Woods, Wayne Co.
(Lindsey and Escobar 1976, Pell and Mack 1977)

Holden Arboretum, Lake Co.
(Pell and Mack 1977)

Hueston Woods Nature Preserve, Preble Co.
(Adams and Barrett 1977; Auten 1933; Davis 1993; Fore *et al.* 1992; Lindsey and Escobar 1976; Moore and Vankat 1986; Osborne 1984; Roberts *et al.* 1984; Roberts and Vankat 1991; Rogers 1982; Runkle 1981, 1982, 1984, 1985, 1990; Runkle *et al.* 1984; Snider 1984; Snyder and Vankat 1984; Vankat 1991; Vankat *et al.* 1975; Vankat and Carson 1991; Vankat and Snyder 1991; Williamson and Powell 1984)

Kimball Woods, Lake Co.
(Lindsey and Escobar 1976, Pell and Mack 1977)

Sears-Carmean Woods, Crawford Co.
(Cho and Boerner 1991a, 1991b; Davis 1993)

Sigrist Woods, Stark Co.
(Lindsey and Escobar 1976)

Tinker's Creek, Cuyahoga Co.
(Lindsey and Escobar 1976, Pell and Mack 1977)

Tschantz Woods, Wyandot Co.
(Rogers 1982)

University School Forest, Cuyahoga Co.
(Schlesinger 1971)

Williams Memorial Woods, Cuyahoga Co.
(Lindsey and Escobar 1976, Pell and Mack 1977, Williams 1936)

Winton Woods, Hamilton Co.
(Bryant 1987)

Pennsylvania

McConnells Mill State Park, Lawrence Co.
(Davis 1993, Lindsey and Escobar 1976)

Tyron-Weber Woods, Crawford Co.
(Davis 1993, Smith 1989)

Wisconsin

Abraham's Woods, Green Co.
(Harper 1963, Lindsey and Escobar 1976, Maher 1988, Rogers 1982, Warner 1963)

Adell Woods, Sheboygan Co.
(Lindsey and Escobar 1976)

Baxter's Hollow, Sauk Co.
(Davis 1993, Maher 1988)

Cleveland Woods, Manitowac Co.
(Rogers 1981, 1982)

Hunt Hill, Washburn Co.
(Eggler 1938, Tyrrell 1988d)

Jericho Woods, Calumet Co.
(Lindsey and Escobar 1976; Rogers 1981, 1982)

Renak-Polak Woods, Racine Co.
(Davis 1993, Maher 1988)

Schmidt (Fernwold) Woods, Clark Co.
(Landaal 1986, Lindsey and Escobar 1976, Schmidt 1931)

Spring Grove Woods, Green Co.
(Harper 1963, Lindsey and Escobar 1976, Steinbrenner 1951, Struik and Curtis 1962)

Waupun Woods, Fond du Lac Co.
(Leitner 1988e; Lindsey and Escobar 1976; Rogers 1981, 1982)

Canada

Muir's Woods, Quebec
(Brisson *et al.* 1988, 1992)

FOR ADDITIONAL INFORMATION

Additional references that pertain to beech-maple-basswood forests but are not cited in tables or text, are listed by forest type group in Appendix C.

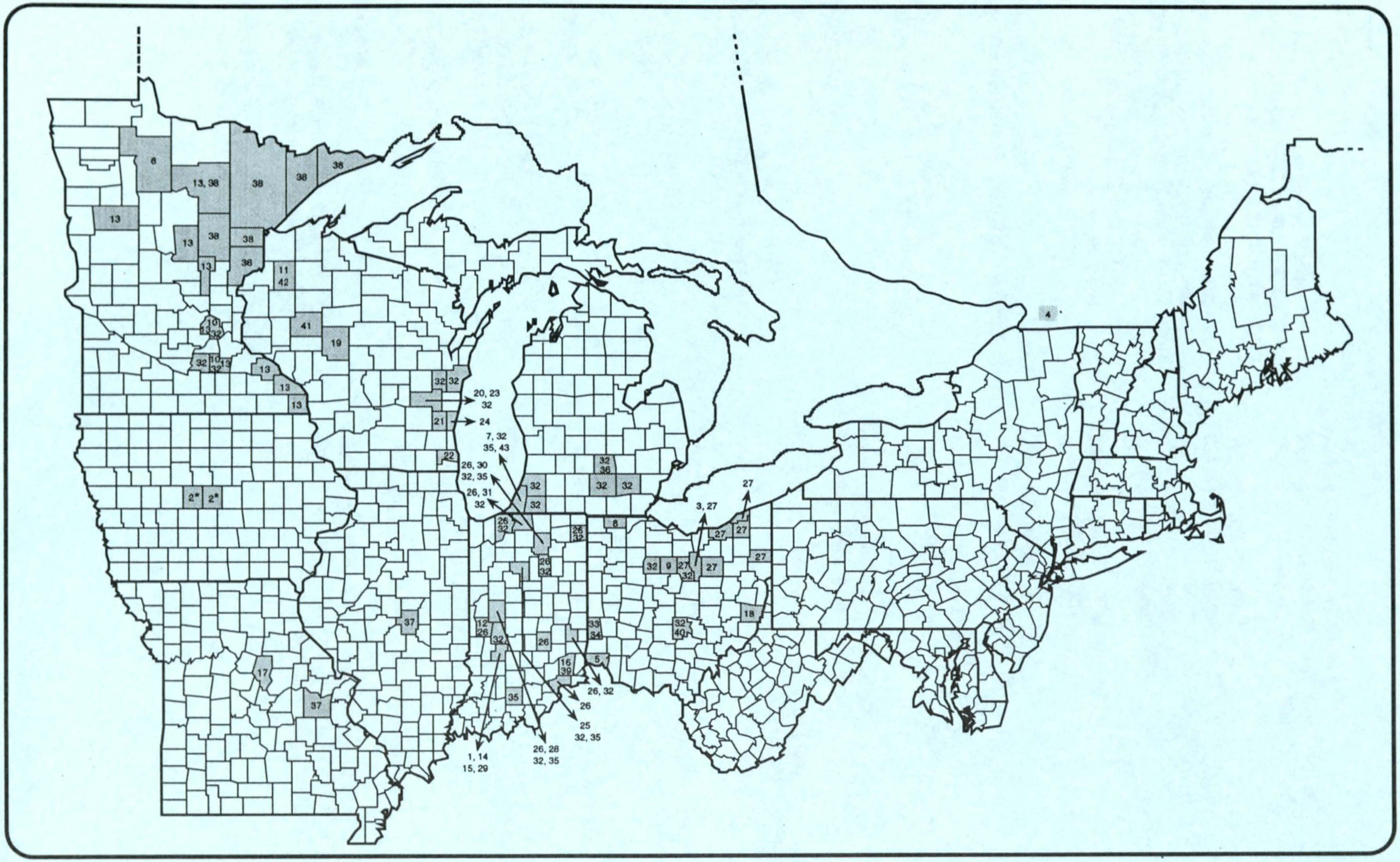
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Figure 4.—*General location of studies that provide stand structure information about old-growth beech-maple-basswood forests. Shaded counties contain at least one study. Numbers correspond to the cited references listed under Map Key below and in Tables 7 through 16. States are indicated using two-letter postal abbreviations. An asterisk indicates that the county is probable, but not certain.*

Map Key	Source/Date	State or Province	County
1	Abrell and Jackson 1977	IN	Owen
2	Aikman and Smelser 1938	IA	Story*, Boone*
3	Aughanbaugh 1964	OH	Ashland
4	Brisson et al. 1992	Quebec	[45°11'N, 74°7'W]
5	Bryant 1987	OH	Hamilton
6	Buell and Bormann 1955	MN	Beltrami
7	Cain 1935	MI	Berrien
8	Cho and Boerner 1991a	OH	Crawford, Fulton
9	Cho and Boerner 1991b	OH	Crawford
10	Daubenmire 1936	MN	Hennepin, Rice
11	Eggler 1938	WI	Washburn
12	Esten 1932	IN	Parke
13	Hale 1996	MN	Becker, Crow Wing, Hennepin, Houston, Itasca, Mille Lacs, Rice, Wabasha, Winona
14	Jackson and Abrell 1977	IN	Owen
15	Jackson and Allen 1967	IN	Owen
16	Jackson and Allen 1969	IN	Ripley
17	Kucera and McDermott 1955	MO	Boone
18	Lafer and Wistendahl 1970	OH	Belmont
19	Landaal 1986	WI	Clark
20	Leitner 1988a	WI	Fond du Lac
21	Leitner 1988b	WI	Washington
22	Leitner 1988c	WI	Racine
23	Leitner 1988e	WI	Fond du Lac
24	Leitner 1989b	WI	Ozaukee
25	Lindsey et al. 1961	IN	Cass
26	Lindsey et al. 1969	IN	DeKalb, Fayette, Jefferson, Kosciusko, LaPorte, Montgomery, Parke, Shelby, St. Joseph, Wabash
27	Pell and Mack 1977	OH	Ashland, Cuyahoga, Geauga, Lake, Mahoning, Richland, Wayne
28	Petty and Harwood 1964	IN	Montgomery
29	Petty and Lindsey 1962	IN	Owen
30	Potzger and Friesner 1943	IN	Kosciusko
31	Riemenschneider and Blodgett 1983	IN	St. Joseph
32	Rogers 1992	IN	Cass, DeKalb, Fayette, Kosciusko, LaPorte, Montgomery, Putnam, St. Joseph, Wabash
		MI	Berrien, Cass, Ingham, Jackson, Van Buren, Washtenaw
		MN	Hennepin, LeSueur, Rice
		OH	Fairfield, Richland, Wyandot
		WI	Calumet, Fond du Lac, Manitowac
33	Runkle 1982	OH	Preble
34	Runkle et al. 1984	OH	Preble
35	Schmelz 1964	IN	Cass, Kosciusko, Montgomery, Orange
		MI	Berrien
36	Schneider 1963	MI	Ingham
37	Spetich et al. 1996	MO	Franklin
		IL	Macon
38	Stai and Mladenoff 1993	MN	Aitken, Carlton, Cook, Itasca, Lake, St. Louis, Pine
39	Stearns 1956	IN	Ripley
40	Sudia 1960	OH	Fairfield
41	Thompson 1991	WI	Chippewa
42	Tyrrell 1988d	WI	Washburn
43	Woods 1979	MI	Berrien

Table 7.—*Location, size, and elevation of beech-maple-basswood old-growth study sites. Asterisks indicate that county location is likely, but not certain. Brackets indicate that the latitude and longitude were estimated from maps or information included in the cited reference.*

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
1	Abrell and Jackson 1977 [1]	Hoot	IN	Owen	26	unspecified
2	Aikman and Smelser 1938	North Woods Tract	IA	Story*, Boone*	12	unspecified
3	Aughanbaugh 1964 [2]	Crall	OH	Ashland	16	357
4	Brisson et al. 1992	Muir's	Quebec	[45°11'N, 74°7'W]	11	unspecified
5	Bryant 1987	Winton	OH	Hamilton	unspecified	unspecified
6	Buell and Bormann 1955	Ponemah Point	MN	Beltrami	unspecified	357-387
7	Cain 1935	Warren	MI	Berrien	4	unspecified
8	Cho and Boerner 1991a	Goll	OH	Fulton	146	unspecified
8	Cho and Boerner 1991a	Sears/Carmean	OH	Crawford	71	unspecified
9	Cho and Boerner 1991b	Sears/Carmean	OH	Crawford	63	290-300
10	Daubenmire 1936	Minnetonka	MN	Hennepin	unspecified	unspecified
10	Daubenmire 1936	Northfield	MN	Rice	unspecified	unspecified
11	Eggler 1938	East	WI	Washburn	unspecified	396
11	Eggler 1938	Hunt Hill	WI	Washburn	32	396
11	Eggler 1938	Long Lake	WI	Washburn	unspecified	396
12	Esten 1932	Turkey Run State Park--Rocky Hollow	IN	Parke	unspecified	unspecified
13	Hale 1996	11 forests in Minnesota	MN	listed below	5-57	256-460
13	Hale 1996	Bello	MN	Itasca	8	430
13	Hale 1996	Big Island	MN	Crowwing	16	378
13	Hale 1996	Dinosaur Island	MN	Mille Lacs	36	378
13	Hale 1996	Lowry Woods	MN	Hennepin	8	302
13	Hale 1996	Richardson	MN	Wabasha	10	256
13	Hale 1996	St. Charl-dog	MN	Winona	11	338
13	Hale 1996	Sugarbush	MN	Becker	57	460
13	Hale 1996	Taylor Woods	MN	Hennepin	40	280
13	Hale 1996	Townsend	MN	Rice	12	332
13	Hale 1996	Wolsfeld--old growth	MN	Hennepin	5	323
13	Hale 1996	Wray	MN	Houston	8	293
14	Jackson and Abrell 1977 [3]	Hoot	IN	Owen	26	unspecified
15	Jackson and Allen 1967	Hoot	IN	Owen	26	unspecified
16	Jackson and Allen 1969 [4]	Versailles State Park--Jackson	IN	Ripley	10	unspecified
16	Jackson and Allen 1969 [4]	Versailles State Park--Potzger	IN	Ripley	4	unspecified
17	Kucera and McDermott 1955	Douglas	MO	Boone	6	unspecified
17	Kucera and McDermott 1955	Schnabel	MO	Boone	unspecified	unspecified
18	Lafer and Wistendahl 1970	Dysart North	OH	Belmont	9	unspecified
18	Lafer and Wistendahl 1970	Dysart South	OH	Belmont	9	unspecified
19	Landaal 1986	Schmidt	WI	Clark	15	326-344

(Table 7 continued on next page)

(Table 7 continued)

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
20	Leitner 1988a	Haskell Noyes Memorial Woods	WI	Fond du Lac	21	unspecified
21	Leitner 1988b	Kewaskum Maple - Oak Woods	WI	Washington	20	unspecified
22	Leitner 1988c	Renak - Polak Maple - Beech Woods	WI	Racine	19	unspecified
23	Leitner 1988e	Waupun Park Maple Forest	WI	Fond du Lac	16	unspecified
24	Leitner 1989b	Kurtz Woods	WI	Ozaukee	12	unspecified
25	Lindsey et al. 1961	Logansport	IN	Cass	unspecified	unspecified
26	Lindsey et al. 1969	Allee	IN	Parke	2	168-200
26	Lindsey et al. 1969	Bendix	IN	St. Joseph	12	unspecified
26	Lindsey et al. 1969	Casters	IN	Montgomery	17	250-262
26	Lindsey et al. 1969	Kado-Lato	IN	DeKalb	12	unspecified
26	Lindsey et al. 1969	LaPorte--South	IN	LaPorte	11	unspecified
26	Lindsey et al. 1969	Manlove	IN	Fayette	36	323
26	Lindsey et al. 1969	Meltzer--upland site; Crosby soil	IN	Shelby	19	259
26	Lindsey et al. 1969	Officers' Woods North	IN	Jefferson	34	213-244
26	Lindsey et al. 1969	Ogden	IN	Wabash	6	unspecified
26	Lindsey et al. 1969	Rosbrugh	IN	Kosciusko	13	265-271
26	Lindsey et al. 1969	Turkey Run State Park--Rocky Hollow	IN	Parke	unspecified	168
26	Lindsey et al. 1969	Weaver	IN	Fayette	12	unspecified
27	Pell and Mack 1977	Ansell's Ledge	OH	Geauga	unspecified	405
27	Pell and Mack 1977	Bole	OH	Geauga	unspecified	335
27	Pell and Mack 1977	Crall	OH	Ashland	unspecified	355
27	Pell and Mack 1977	Firestone	OH	Mahoning	unspecified	365
27	Pell and Mack 1977	Fowler	OH	Richland	unspecified	390
27	Pell and Mack 1977	Graber	OH	Wayne	unspecified	370
27	Pell and Mack 1977	Holden Arboretum	OH	Lake	unspecified	290
27	Pell and Mack 1977	Kimball	OH	Lake	unspecified	265
27	Pell and Mack 1977	Tinker's Creek	OH	Cuyahoga	unspecified	276
27	Pell and Mack 1977	Williams	OH	Cuyahoga	unspecified	290
28	Petty and Harwood 1964	Rush	IN	Montgomery	unspecified	unspecified
29	Petty and Lindsey 1962	Hoot	IN	Owen	26	unspecified
30	Potzger and Friesner 1943	Berkey	IN	Kosciusko	unspecified	unspecified
31	Riemenschneider and Blodgett 1983	Bendix	IN	St. Joseph	12	unspecified
32	Rogers 1992	Bangham	MI	Jackson	unspecified	unspecified
32	Rogers 1992	Bendix	IN	St. Joseph	unspecified	unspecified
32	Rogers 1992	Big Walnut Preserve--Heron	IN	Putnam	unspecified	unspecified
32	Rogers 1992	Blacklick	OH	Fairfield	unspecified	unspecified
32	Rogers 1992	Cedar Lake	MN	Rice	unspecified	unspecified

(Table 7 continued on next page)

(Table 7 continued)

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
32	Rogers 1992	Cleveland	WI	Manitowac	unspecified	unspecified
32	Rogers 1992	Diamond Lake	MN	Hennepin	unspecified	unspecified
32	Rogers 1992	First	MI	Berrien	unspecified	unspecified
32	Rogers 1992	Fowler	OH	Richland	unspecified	unspecified
32	Rogers 1992	Fuller	MI	Van Buren	unspecified	unspecified
32	Rogers 1992	Henry	MN	Hennepin	unspecified	unspecified
32	Rogers 1992	Hultz	IN	Putnam	unspecified	unspecified
32	Rogers 1992	Jericho	WI	Calumet	unspecified	unspecified
32	Rogers 1992	Kado-Lato	IN	DeKalb	unspecified	unspecified
32	Rogers 1992	LaPorte	IN	LaPorte	unspecified	unspecified
32	Rogers 1992	Limbeck	MN	Hennepin	unspecified	unspecified
32	Rogers 1992	Logansport	IN	Cass	unspecified	unspecified
32	Rogers 1992	Lyon	MI	Ingham	unspecified	unspecified
32	Rogers 1992	Manlove	IN	Fayette	unspecified	unspecified
32	Rogers 1992	Morgan	MI	Washtenaw	unspecified	unspecified
32	Rogers 1992	Nerstrand	MN	Rice	unspecified	unspecified
32	Rogers 1992	Ogden	IN	Wabash	unspecified	unspecified
32	Rogers 1992	Richter	MN	LeSueur	unspecified	unspecified
32	Rogers 1992	Rosbrugh	IN	Kosciusko	unspecified	unspecified
32	Rogers 1992	Rush	IN	Montgomery	unspecified	unspecified
32	Rogers 1992	Russ (Newton)	MI	Cass	unspecified	unspecified
32	Rogers 1992	Shades State Park--Trail 2	IN	Montgomery	unspecified	unspecified
32	Rogers 1992	Shades State Park--Trail 5	IN	Montgomery	unspecified	unspecified
32	Rogers 1992	Taylor	MN	Hennepin	unspecified	unspecified
32	Rogers 1992	Toumey	MI	Ingham	unspecified	unspecified
32	Rogers 1992	Tschantz	OH	Wyandot	unspecified	unspecified
32	Rogers 1992	Warren	MI	Berrien	unspecified	unspecified
32	Rogers 1992	Waupun	WI	Fond du Lac	unspecified	unspecified
32	Rogers 1992	Weaver	IN	Fayette	unspecified	unspecified
32	Rogers 1992	Wolsfeld	MN	Hennepin	unspecified	unspecified
33	Runkle 1982	Hueston	OH	Preble	unspecified	unspecified
34	Runkle et al. 1984	Hueston	OH	Preble	67	unspecified
35	Schmelz 1964	Logansport	IN	Cass	unspecified	unspecified
35	Schmelz 1964	Pine Hills	IN	Montgomery	unspecified	unspecified
35	Schmelz 1964	Pioneer Mothers	IN	Orange	32	unspecified
35	Schmelz 1964	Rosbrugh	IN	Kosciusko	13	unspecified
35	Schmelz 1964	Warren	MI	Berrien	8	unspecified

(Table 7 continued on next page)

(Table 7 continued)

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
36	Schneider 1963	Toumey	MI	Ingham	6	259-271
37	Spetich et al. 1996	Engelmann Woods	MO	Franklin	unspecified	unspecified
37	Spetich et al. 1996	Spitler Woods	IL	Macon	unspecified	unspecified
38	Stai and Mladenoff 1993	Bowstring Lake	MN	Itasca	unspecified	unspecified
38	Stai and Mladenoff 1993	Ludwig Management Area	MN	Pine	unspecified	unspecified
38	Stai and Mladenoff 1993	Moose Mountain Scientific and Natural Area	MN	St. Louis	unspecified	unspecified
38	Stai and Mladenoff 1993	Mt. Trudee	MN	Lake	unspecified	unspecified
38	Stai and Mladenoff 1993	New Dosey	MN	Pine	unspecified	unspecified
38	Stai and Mladenoff 1993	Nipisiquit Lake	MN	Lake	unspecified	unspecified
38	Stai and Mladenoff 1993	Prairie River	MN	Aitken	unspecified	unspecified
38	Stai and Mladenoff 1993	Savanna Prairie	MN	Aitken	unspecified	unspecified
38	Stai and Mladenoff 1993	Soo Line Railroad	MN	Carlton	unspecified	unspecified
38	Stai and Mladenoff 1993	Spring Beauty Scientific and Natural Area	MN	Cook	unspecified	unspecified
38	Stai and Mladenoff 1993	Tom Lake	MN	Cook	unspecified	unspecified
39	Stearns 1956	Versailles State Park--Potzger	IN	Ripley	unspecified	unspecified
40	Sudia 1960	Blacklick	OH	Fairfield	24	unspecified
41	Thompson 1991	Plagge Woods	WI	Chippewa	32	396-442
42	Tyrrell 1988d	Hunt Hill	WI	Washburn	30	unspecified
43	Woods 1979	Warren	MI	Berrien	unspecified	unspecified

[1] See also Jackson and Abrell (1977).

[2] Lindsey and Escobar (1976) also cite this study.

[3] See also Abrell and Jackson (1977).

[4] Also given in Lindsey et al. (1969).

Table 8.—*Criteria used by sources to identify old-growth stands, and information about stand composition of beech-maple-basswood old-growth study sites.*

Map Key	Source/Date	Stand	Criteria for Stand Selection and Stand Composition
1	Abrell and Jackson 1977	Hoot	Old growth; beech-maple
2	Aikman and Smelser 1938	North Woods Tract	Small tract of virgin forest
3	Aughanbaugh 1964	Crall	Near-original forest remnant of exceptional beauty
4	Brisson et al. 1992	Muir's	Few signs of human disturbance; beech-maple
5	Bryant 1987	Winton	Old-growth forests; little-disturbed
6	Buell and Bormann 1955	Ponemah Point	Most magnificent of the original deciduous forest still existing in the State
7	Cain 1935	Warren	Virgin forest
8	Cho and Boerner 1991a	Goll	Old-growth forest remnant
8	Cho and Boerner 1991a	Sears/Carmean	Essentially undisturbed woods
9	Cho and Boerner 1991b	Sears/Carmean	Essentially undisturbed woods
10	Daubenmire 1936	Minnetonka	Near-virgin stand
10	Daubenmire 1936	Northfield	Near-virgin stand
11	Eggler 1938	East	Undisturbed hardwoods
11	Eggler 1938	Hunt Hill	Undisturbed hardwoods
11	Eggler 1938	Long Lake	Undisturbed hardwoods
12	Esten 1932	Turkey Run State Park--Rocky Hollow	Virgin; beech-maple association
13	Hale 1996	11 forests in Minnesota	>120 yr stand age; no significant disturbance [1]; maple-basswood
13	Hale 1996	Bello	>120 yr stand age; no significant disturbance [1]; maple-basswood (88% combined)
13	Hale 1996	Big Island	>120 yr stand age; no significant disturbance [1]; maple-basswood (36% combined)
13	Hale 1996	Dinosaur Island	>120 yr stand age; no significant disturbance [1]; maple-basswood (73% combined)
13	Hale 1996	Lowry Woods	>120 yr stand age; no significant disturbance [1]; maple-basswood (47% combined)
13	Hale 1996	Richardson	>120 yr stand age; no significant disturbance [1]; maple-basswood (93% combined)
13	Hale 1996	St. Charl-dog	>120 yr stand age; no significant disturbance [1]; maple-basswood (79% combined)
13	Hale 1996	Sugarbush	>120 yr stand age; no significant disturbance [1]; maple-basswood (95% combined)
13	Hale 1996	Taylor Woods	>120 yr stand age; no significant disturbance [1]; maple-basswood (92% combined)
13	Hale 1996	Townsend	>120 yr stand age; no significant disturbance [1]; maple-basswood (82% combined)
13	Hale 1996	Wolsfeld--old growth	>120 yr stand age; no significant disturbance [1]; maple-basswood (87% combined)
13	Hale 1996	Wray	>120 yr stand age; no significant disturbance [1]; maple-basswood (68% combined)
14	Jackson and Abrell 1977	Hoot	Old growth; beech-maple
15	Jackson and Allen 1967	Hoot	Old growth; beech-maple
16	Jackson and Allen 1969	Versailles State Park--Jackson	Best remaining old-growth forest in the area
16	Jackson and Allen 1969	Versailles State Park--Potzger	Old-growth forest
17	Kucera and McDermott 1955	Douglas	Stand representative of the original forest; maple-basswood
17	Kucera and McDermott 1955	Schnabel	Stand representative of the original forest; maple-basswood
18	Lafer and Wistendahl 1970	Dysart North	Oldest known relatively undisturbed forest in unglaciated southeastern Ohio
18	Lafer and Wistendahl 1970	Dysart South	Oldest known relatively undisturbed forest in unglaciated southeastern Ohio
19	Landaal 1986	Schmidt	One of the best examples remaining in this portion of the State

(Table 8 continued on next page)

(Table 8 continued)

Map Key	Source/Date	Stand	Criteria for Stand Selection and Stand Composition
20	Leitner 1988a	Haskell Noyes Memorial Woods	Forest of State significance purchased in 1947 to prevent logging; sugar maple-red oak-basswood
21	Leitner 1988b	Kewaskum Maple - Oak Woods	State significant forest; selectively cut in the distant past; maple-oak-ash-basswood
22	Leitner 1988c	Renak - Polak Maple - Beech Woods	State significant forest; minimal fuelwood cutting, light grazing in the past; maple-basswood-beech
23	Leitner 1988e	Waupun Park Maple Forest	State significant old-growth forest; some logging has taken place, some recreational impacts; maple
24	Leitner 1989b	Kurtz Woods	Remnant of presettlement forest; little disturbance in last 60-70 years [2]
25	Lindsey et al. 1961	Logansport	Climatic climax; beech-sugar maple
26	Lindsey et al. 1969	Allee	Relatively undisturbed; former sugar bush
26	Lindsey et al. 1969	Bendix	Old growth; protected since 1926
26	Lindsey et al. 1969	Casters	Good example of beech-maple forest; old sugar camp
26	Lindsey et al. 1969	Kado-Lato	Old-growth woods; formerly used as a sugar bush
26	Lindsey et al. 1969	LaPorte--South	Mature woods; some recent cutting
26	Lindsey et al. 1969	Manlove	Former sugar bush
26	Lindsey et al. 1969	Meltzer--upland site; Crosby soil	Museum-piece forest with particularly fine, large individual specimens
26	Lindsey et al. 1969	Officers' Woods North	Fine old-growth timber
26	Lindsey et al. 1969	Ogden	Essentially a virgin stand
26	Lindsey et al. 1969	Rosbrugh	Sugar bush for over 100 yr
26	Lindsey et al. 1969	Turkey Run State Park--Rocky Hollow	Virgin
26	Lindsey et al. 1969	Weaver	Essentially undisturbed climax; maple-beech
27	Pell and Mack 1977	Ansell's Ledge	Stand with large trees; relatively little evidence of fire, logging, or grazing
27	Pell and Mack 1977	Bole	Stand with large trees; relatively little evidence of fire, logging, or grazing
27	Pell and Mack 1977	Crall	Stand with large trees; relatively little evidence of fire, logging, or grazing
27	Pell and Mack 1977	Firestone	Stand with large trees; relatively little evidence of fire, logging, or grazing
27	Pell and Mack 1977	Fowler	Stand with large trees; relatively little evidence of fire, logging, or grazing
27	Pell and Mack 1977	Graber	Stand with large trees; relatively little evidence of fire, logging, or grazing
27	Pell and Mack 1977	Holden Arboretum	Stand with large trees; relatively little evidence of fire, logging, or grazing
27	Pell and Mack 1977	Kimball	Stand with large trees; relatively little evidence of fire, logging, or grazing
27	Pell and Mack 1977	Tinker's Creek	Stand with large trees; relatively little evidence of fire, logging, or grazing
27	Pell and Mack 1977	Williams	Stand with large trees; relatively little evidence of fire, logging, or grazing
28	Petty and Harwood 1964	Rush	Remnant of virgin timber
29	Petty and Lindsey 1962	Hoot	Virgin timber
30	Potzger and Friesner 1943	Berkey	Relatively undisturbed stand
31	Riemenschneider and Blodgett 1983	Bendix	Good example of old-growth beech-maple forest
32	Rogers 1992	Bangham	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Bendix	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Big Walnut Preserve--Heron	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Blacklick	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Cedar Lake	Closed-canopy, old growth; mesic sugar maple-dominated forest

(Table 8 continued on next page)

(Table 8 continued)

Map Key	Source/Date	Stand	Criteria for Stand Selection and Stand Composition
32	Rogers 1992	Cleveland	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Diamond Lake	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	First	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Fowler	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Fuller	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Henry	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Hultz	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Jericho	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Kado-Lato	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	LaPorte	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Limbeck	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Logansport	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Lyon	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Manlove	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Morgan	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Nerstrand	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Ogden	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Richter	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Rosbrugh	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Rush	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Russ (Newton)	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Shades State Park--Trail 2	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Shades State Park--Trail 5	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Taylor	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Toumey	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Tschantz	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Warren	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Waupun	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Weaver	Closed-canopy, old growth; mesic sugar maple-dominated forest
32	Rogers 1992	Wolsfeld	Closed-canopy, old growth; mesic sugar maple-dominated forest
33	Runkle 1982	Hueston	Old-growth mesic forest
34	Runkle et al. 1984	Hueston	Remnant old growth; beech-maple
35	Schmelz 1964	Logansport	No evidence of cutting
35	Schmelz 1964	Pine Hills	Virgin; beech-maple
35	Schmelz 1964	Pioneer Mothers	Original forest; beech-maple
35	Schmelz 1964	Rosbrugh	Old sugar bush
35	Schmelz 1964	Warren	Old-growth forest

(Table 8 continued on next page)

(Table 8 continued)

Map Key	Source/Date	Stand	Criteria for Stand Selection and Stand Composition
36	Schneider 1963	Toumey	Relatively undisturbed; maple-beech forest
37	Spetich et al. 1996	Engelmann Woods	Multilayered canopyies of trees >150 yr; minimal human-caused disturbance during past 80-100 yr
37	Spetich et al. 1996	Spitler Woods	Multilayered canopyies of trees >150 yr; minimal human-caused disturbance during past 80-100 yr
38	Stai and Mladenoff 1993	Bowstring Lake	Age of trees in stand >120 yr; relatively undisturbed [3]
38	Stai and Mladenoff 1993	Ludwig Management Area	Age of trees in stand >120 yr; relatively undisturbed [3]
38	Stai and Mladenoff 1993	Moose Mountain Scientific and Natural Area	Age of trees in stand >120 yr; relatively undisturbed [3]
38	Stai and Mladenoff 1993	Mt. Trudee	Age of trees in stand >120 yr; relatively undisturbed [3]
38	Stai and Mladenoff 1993	New Dosey	Age of trees in stand >120 yr; relatively undisturbed [3]
38	Stai and Mladenoff 1993	Nipisiquit Lake	Age of trees in stand >120 yr; relatively undisturbed [3]
38	Stai and Mladenoff 1993	Prairie River	Age of trees in stand >120 yr; relatively undisturbed [3]
38	Stai and Mladenoff 1993	Savanna Prairie	Age of trees in stand >120 yr; relatively undisturbed [3]
38	Stai and Mladenoff 1993	Soo Line Railroad	Age of trees in stand >120 yr; relatively undisturbed [3]
38	Stai and Mladenoff 1993	Spring Beauty Scientific and Natural Area	Age of trees in stand >120 yr; relatively undisturbed [3]
38	Stai and Mladenoff 1993	Tom Lake	Age of trees in stand >120 yr; relatively undisturbed [3]
39	Stearns 1956	Versailles State Park--Potzger	Old-growth forest on level, well drained, residual soil
40	Sudia 1960	Blacklick	No canopy opening over stumps; few trees cut (mostly white ash)
41	Thompson 1991	Plagge Woods	Old growth; cut only sporadically <1920; intermittent grazing in the past; maple-basswood-oak
42	Tyrrell 1988d	Hunt Hill	Forest described by Eggler 1938 as "nearly virgin" in 1935; no major disturbance; oak-maple-basswood
43	Woods 1979	Warren	Essentially undisturbed remnant; beech-maple

[1] No visible evidence of significant natural or human induced disturbance.

[2] Ice storm occurred in the winter of 1975-76 when many branches fell; dead wood was later removed.

[3] May be northern hardwoods rather than maple-basswood.

Table 9.—*Methods used to study old-growth beech-maple-basswood (condensed from the cited references).*

Map Key	Source/Date	Stand	Sampling Methods
1	Abrell and Jackson 1977	Hoot	Full tree tally on 4.4 ha
2	Aikman and Smelser 1938	North Woods Tract	Tree tally based on 5 0.04-ha quadrats
3	Aughanbaugh 1964	Crall	General inventory
4	Brisson et al. 1992	Muir's	Full tree tally of forest
5	Bryant 1987	Winton	All trees >10 cm d.b.h. sampled within 0.04-ha circular plots
6	Buell and Bormann 1955	Ponemah Point	Full tree tally within 10 100-m^2 plots
7	Cain 1935	Warren	Full tree census within 25 100-m^2 plots
8	Cho and Boerner 1991a	Goll	44 100-m^2 quadrats sampled along line transects
8	Cho and Boerner 1991a	Sears/Carmean	94 100-m^2 plots sampled
9	Cho and Boerner 1991b	Sears/Carmean	73 100-m^2 quadrats sampled randomly along transects
10	Daubenmire 1936	Minnetonka	Full tree tally within 25 100-m^2 plots
10	Daubenmire 1936	Northfield	Full tree tally within 25 100-m^2 plots
11	Eggler 1938	East	4 100-m^2 plots sampled for trees
11	Eggler 1938	Hunt Hill	25 100-m^2 plots sampled for trees
11	Eggler 1938	Long Lake	21 100-m^2 plots sampled for trees
12	Esten 1932	Turkey Run State Park--Rocky Hollow	Trees sampled within 25 100-m^2 quadrats
13	Hale 1996	11 forests in Minnesota	1 20 m x 50 m plot per stand; 4 2 m x 100 m transects per stand
13	Hale 1996	Bello	1 20 m x 50 m plot; 4 2 m x 100 m transects
13	Hale 1996	Big Island	1 20 m x 50 m plot; 4 2 m x 100 m transects
13	Hale 1996	Dinosaur Island	1 20 m x 50 m plot; 4 2 m x 100 m transects
13	Hale 1996	Lowry Woods	1 20 m x 50 m plot; 4 2 m x 100 m transects
13	Hale 1996	Richardson	1 20 m x 50 m plot; 4 2 m x 100 m transects
13	Hale 1996	St. Charl-dog	1 20 m x 50 m plot; 4 2 m x 100 m transects
13	Hale 1996	Sugarbush	1 20 m x 50 m plot; 4 2 m x 100 m transects
13	Hale 1996	Taylor Woods	1 20 m x 50 m plot; 4 2 m x 100 m transects
13	Hale 1996	Townsend	1 20 m x 50 m plot; 4 2 m x 100 m transects
13	Hale 1996	Wolsfeld--old growth	1 20 m x 50 m plot; 4 2 m x 100 m transects
13	Hale 1996	Wray	1 20 m x 50 m plot; 4 2 m x 100 m transects
14	Jackson and Abrell 1977	Hoot	Full tree tally on 4.4 ha
15	Jackson and Allen 1967	Hoot	Full tree tally on 4.4 ha
16	Jackson and Allen 1969	Versailles State Park--Jackson	Full tree tally on 7.1 ha
16	Jackson and Allen 1969	Versailles State Park--Potzger	Full tree tally on 2.6 ha
17	Kucera and McDermott 1955	Douglas	Random pairs method using a 1 chain interval between plots
17	Kucera and McDermott 1955	Schnabel	Random pairs method using a 1 chain interval between plots
18	Lafer and Wistendahl 1970	Dysart North	Random pairs method comprised of 125 plots
18	Lafer and Wistendahl 1970	Dysart South	Random pairs method comprised of 125 plots
19	Landaal 1986	Schmidt	Vegetation sampled within 250-m^2 rectangular plots along line strips [1]

(Table 9 continued on next page)

(Table 9 continued)

Map Key	Source/Date	Stand	Sampling Methods
20	Leitner 1988a	Haskell Noyes Memorial Woods	Trees >10 cm in 20 10 m x 25 m plots located on a grid
21	Leitner 1988b	Kewaskum Maple - Oak Woods	Trees >10 cm in 20 10 m x 25 m plots located on a grid
22	Leitner 1988c	Renak - Polak Maple - Beech Woods	Trees >10 cm in 20 10 m x 25 m plots located on a grid
23	Leitner 1988e	Waupun Park Maple Forest	Trees >10 cm in 20 10 m x 25 m plots located on a grid
24	Leitner 1989b	Kurtz Woods	Trees >10 cm in 20 10 m x 25 m plots located on a grid
25	Lindsey et al. 1961	Logansport	Complete census of 1.4 ha
26	Lindsey et al. 1969	Allee	Full tree tally on 2 ha
26	Lindsey et al. 1969	Bendix	Full tree tally on 4 ha
26	Lindsey et al. 1969	Casters	Full tree tally on 0.6 ha
26	Lindsey et al. 1969	Kado-Lato	Not reported
26	Lindsey et al. 1969	LaPorte--South	8 sampling strips covering 1.3 ha
26	Lindsey et al. 1969	Manlove	Full tree tally on 5.8 ha
26	Lindsey et al. 1969	Meltzer--upland site; Crosby soil	Tree tally on 10 0.16-ha strips
26	Lindsey et al. 1969	Officers' Woods North	Full tree tally on 3.3 ha (8.2 acres)
26	Lindsey et al. 1969	Ogden	Not reported
26	Lindsey et al. 1969	Rosbrugh	Full tree tally on 7.5 ha
26	Lindsey et al. 1969	Turkey Run State Park--Rocky Hollow	Full tree tally on 2.3 ha
26	Lindsey et al. 1969	Weaver	Full tree tally on 6.7 ha
27	Pell and Mack 1977	Ansell's Ledge	Full tree census within 375-m^2 plot
27	Pell and Mack 1977	Bole	Full tree census within 375-m^2 plot
27	Pell and Mack 1977	Crall	Full tree census within 375-m^2 plot
27	Pell and Mack 1977	Firestone	Full tree census within 375-m^2 plot
27	Pell and Mack 1977	Fowler	Full tree census within 375-m^2 plot
27	Pell and Mack 1977	Graber	Full tree census within 375-m^2 plot
27	Pell and Mack 1977	Holden Arboretum	Full tree census within 375-m^2 plot
27	Pell and Mack 1977	Kimball	Full tree census within 375-m^2 plot
27	Pell and Mack 1977	Tinker's Creek	Full tree census within 375-m^2 plot
27	Pell and Mack 1977	Williams	Full tree census within 375-m^2 plot
28	Petty and Harwood 1964	Rush	Full census on 3.7 ha [2]
29	Petty and Lindsey 1962	Hoot	Full tree tally on 7 ha [3]
30	Potzger and Friesner 1943	Berkey	50 100-m^2 quadrat tally
31	Riemenschneider and Blodgett 1983	Bendix	Full tree tally of 12 ha using 50 m x 50 m grid
32	Rogers 1992	Bangham	Parallel belt transects (20 m wide)
32	Rogers 1992	Bendix	Parallel belt transects (20 m wide)
32	Rogers 1992	Big Walnut Preserve--Heron	Parallel belt transects (20 m wide)
32	Rogers 1992	Blacklick	Parallel belt transects (20 m wide)
32	Rogers 1992	Cedar Lake	Parallel belt transects (20 m wide)

(Table 9 continued on next page)

(Table 9 continued)

Map Key	Source/Date	Stand	Sampling Methods
32	Rogers 1992	Cleveland	Parallel belt transects (20 m wide)
32	Rogers 1992	Diamond Lake	Parallel belt transects (20 m wide)
32	Rogers 1992	First	Parallel belt transects (20 m wide)
32	Rogers 1992	Fowler	Parallel belt transects (20 m wide)
32	Rogers 1992	Fuller	Parallel belt transects (20 m wide)
32	Rogers 1992	Henry	Parallel belt transects (20 m wide)
32	Rogers 1992	Hultz	Parallel belt transects (20 m wide)
32	Rogers 1992	Jericho	Parallel belt transects (20 m wide)
32	Rogers 1992	Kado-Lato	Parallel belt transects (20 m wide)
32	Rogers 1992	LaPorte	Parallel belt transects (20 m wide)
32	Rogers 1992	Limbeck	Parallel belt transects (20 m wide)
32	Rogers 1992	Logansport	Parallel belt transects (20 m wide)
32	Rogers 1992	Lyon	Parallel belt transects (20 m wide)
32	Rogers 1992	Manlove	Parallel belt transects (20 m wide)
32	Rogers 1992	Morgan	Parallel belt transects (20 m wide)
32	Rogers 1992	Nerstrand	Parallel belt transects (20 m wide)
32	Rogers 1992	Ogden	Parallel belt transects (20 m wide)
32	Rogers 1992	Richter	Parallel belt transects (20 m wide)
32	Rogers 1992	Rosbrugh	Parallel belt transects (20 m wide)
32	Rogers 1992	Rush	Parallel belt transects (20 m wide)
32	Rogers 1992	Russ (Newton)	Parallel belt transects (20 m wide)
32	Rogers 1992	Shades State Park--Trail 2	Parallel belt transects (20 m wide)
32	Rogers 1992	Shades State Park--Trail 5	Parallel belt transects (20 m wide)
32	Rogers 1992	Taylor	Parallel belt transects (20 m wide)
32	Rogers 1992	Toumey	Parallel belt transects (20 m wide)
32	Rogers 1992	Tschantz	Parallel belt transects (20 m wide)
32	Rogers 1992	Warren	Parallel belt transects (20 m wide)
32	Rogers 1992	Waupun	Parallel belt transects (20 m wide)
32	Rogers 1992	Weaver	Parallel belt transects (20 m wide)
32	Rogers 1992	Wolsfeld	Parallel belt transects (20 m wide)
33	Runkle 1982	Hueston	Point-centered quarter method along transects
34	Runkle et al. 1984	Hueston	Vegetation survey within a 1-ha plot
35	Schmelz 1964	Logansport	Full tree tally on 2.7 ha [4]
35	Schmelz 1964	Pine Hills	Full tree tally on 1.1 ha [5]
35	Schmelz 1964	Pioneer Mothers	Full tree tally on 5.2 ha [4]
35	Schmelz 1964	Rosbrugh	Areal strip method covering 0.8 ha [6]
35	Schmelz 1964	Warren	Full tree tally on 8.5 ha [7]

(Table 9 continued on next page)

(Table 9 continued)

Map Key	Source/Date	Stand	Sampling Methods
36	Schneider 1963	Toumey	Full tree tally over 163 large plots
37	Spetich et al. 1996	Engelmann Woods	30 0.1-ha plots located along a grid
37	Spetich et al. 1996	Spitler Woods	30 0.1-ha plots located along a grid
38	Stai and Mladenoff 1993	Bowstring Lake	1 20 m x 50 m plot; 5 tree cores
38	Stai and Mladenoff 1993	Ludwig Management Area	1 20 m x 50 m plot; 5 tree cores
38	Stai and Mladenoff 1993	Moose Mountain Scientific and Natural Area	1 20 m x 50 m plot; 5 tree cores
38	Stai and Mladenoff 1993	Mt. Trudee	1 20 m x 50 m plot; 5 tree cores
38	Stai and Mladenoff 1993	New Dosey	1 20 m x 50 m plot; 5 tree cores
38	Stai and Mladenoff 1993	Nipisiquit Lake	1 20 m x 50 m plot; 5 tree cores
38	Stai and Mladenoff 1993	Prairie River	1 20 m x 50 m plot; 5 tree cores
38	Stai and Mladenoff 1993	Savanna Prairie	1 20 m x 50 m plot; 5 tree cores
38	Stai and Mladenoff 1993	Soo Line Railroad	1 20 m x 50 m plot; 5 tree cores
38	Stai and Mladenoff 1993	Spring Beauty Scientific and Natural Area	1 20 m x 50 m plot; 5 tree cores
38	Stai and Mladenoff 1993	Tom Lake	1 20 m x 50 m plot; 5 tree cores
39	Stearns 1956	Versailles State Park--Potzger	Random pairs method for sampling tree component
40	Sudia 1960	Blacklick	Trees >10 cm mapped and measured in 4.4-ha area [8]
41	Thompson 1991	Plagge Woods	Trees >10 cm in 23 10 m x 25 m plots located on a grid
42	Tyrrell 1988d	Hunt Hill	Trees >10 cm in 30 10 m x 10 m plots stratefied randomly along transects; transects 50 m apart
43	Woods 1979	Warren	Tree data gathered from 6 0.1-ha plots

[1] Pre-storm (1980) tree data used.

[2] Lindsey et al. (1969) also refer to this sampling.

[3] Data also given in Schmelz (1964), Schmelz and Lindsey (1965), and Lindsey et al. (1969).

[4] Data also listed in Schmelz and Lindsey (1965) and in Lindsey et al. (1969).

[5] Data also listed in Schmelz and Lindsey (1965) and incorrectly in Lindsey et al. (1969).

[6] Data also listed in Schmelz and Lindsey (1965) for Stand #12 (sugar maple upland).

[7] Data also listed in Schmelz and Lindsey (1965).

[8] Data also listed in Lindsey and Escobar (1976).

Table 10.—*Density of live trees ≥10, ≥50, ≥70 cm for beech-maple-basswood old-growth study sites. For other minimum sizes, the density is listed under ≥X cm", with the minimum size for tallying trees given as "Min Diam X (cm)".*

			Live Tree Density				
Map Key	**Source/Date**	**Stand**	**≥10 cm (#/ha)**	**≥50 cm (#/ha)**	**≥70 cm (#/ha)**	**≥X cm (#/ha)**	**Min Diam X (cm)**
1	Abrell and Jackson 1977	Hoot	199				
2	Aikman and Smelser 1938	North Woods Tract	440	15	0	311	20
3	Aughanbaugh 1964	Crall					
4	Brisson et al. 1992	Muir's					
5	Bryant 1987	Winton	240				
6	Buell and Bormann 1955	Ponemah Point	390				
7	Cain 1935	Warren	292			1012	2.5
8	Cho and Boerner 1991a	Goll					
8	Cho and Boerner 1991a	Sears/Carmean					
9	Cho and Boerner 1991b	Sears/Carmean	414				
10	Daubenmire 1936	Minnetonka	352				
10	Daubenmire 1936	Northfield	528				
11	Eggler 1938	East	772				
11	Eggler 1938	Hunt Hill	660				
11	Eggler 1938	Long Lake	728				
12	Esten 1932	Turkey Run State Park--Rocky Hollow				424	5
13	Hale 1996	11 forests in Minnesota	338	46	14		
13	Hale 1996	Bello	425	25	0		
13	Hale 1996	Big Island	175	13	0		
13	Hale 1996	Dinosaur Island	475	0	0		
13	Hale 1996	Lowry Woods	238	63	0		
13	Hale 1996	Richardson	363	50	0		
13	Hale 1996	St. Charl-dog	338	13	0		
13	Hale 1996	Sugarbush	325	38	13		
13	Hale 1996	Taylor Woods	450	113	63		
13	Hale 1996	Townsend	263	75	25		
13	Hale 1996	Wolsfeld--old growth	388	75	38		
13	Hale 1996	Wray	275	38	13		
14	Jackson and Abrell 1977	Hoot				136	20
15	Jackson and Allen 1967	Hoot	205			141	20
16	Jackson and Allen 1969	Versailles State Park--Jackson	269	47	18	117	20
16	Jackson and Allen 1969	Versailles State Park--Potzger	300	45	20	115	20
17	Kucera and McDermott 1955	Douglas	628				
17	Kucera and McDermott 1955	Schnabel	351				
18	Lafer and Wistendahl 1970	Dysart North					
18	Lafer and Wistendahl 1970	Dysart South					
19	Landaal 1986	Schmidt	460				

(Table 10 continued on next page)

(Table 10 continued)

Map Key	Source/Date	Stand	Live Tree Density ≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X cm (#/ha)	Min Diam X (cm)
20	Leitner 1988a	Haskell Noyes Memorial Woods	382	58			
21	Leitner 1988b	Kewaskum Maple - Oak Woods	356	60			
22	Leitner 1988c	Renak - Polak Maple - Beech Woods	455	33	1.7[1]		
23	Leitner 1988e	Waupun Park Maple Forest	374	54	8[1]		
24	Leitner 1989b	Kurtz Woods	412	20	2[1]		
25	Lindsey et al. 1961	Logansport	208				
26	Lindsey et al. 1969	Allee	376				
26	Lindsey et al. 1969	Bendix	181				
26	Lindsey et al. 1969	Casters	264				
26	Lindsey et al. 1969	Kado-Lato					
26	Lindsey et al. 1969	LaPorte--South	155				
26	Lindsey et al. 1969	Manlove	228				
26	Lindsey et al. 1969	Meltzer--upland site; Crosby soil	304				
26	Lindsey et al. 1969	Officers' Woods North	268				
26	Lindsey et al. 1969	Ogden					
26	Lindsey et al. 1969	Rosbrugh	188				
26	Lindsey et al. 1969	Turkey Run State Park--Rocky Hollow	256				
26	Lindsey et al. 1969	Weaver	291				
27	Pell and Mack 1977	Ansell's Ledge	187	133	80	160	20
27	Pell and Mack 1977	Bole	320	213	107	213	20
27	Pell and Mack 1977	Crall	373	187	80	267	20
27	Pell and Mack 1977	Firestone	160	107	80	107	20
27	Pell and Mack 1977	Fowler	267	107	0	160	20
27	Pell and Mack 1977	Graber	320	133	53	240	20
27	Pell and Mack 1977	Holden Arboretum	293	133	53	187	20
27	Pell and Mack 1977	Kimball	373	80	53	267	20
27	Pell and Mack 1977	Tinker's Creek	293	107	27	133	20
27	Pell and Mack 1977	Williams	213	107	53	160	20
28	Petty and Harwood 1964	Rush	236	29	5	108	20
29	Petty and Lindsey 1962	Hoot	180		10		
30	Potzger and Friesner 1943	Berkey				1288	2.5
31	Riemenschneider and Blodgett 1983	Bendix	161			636	4
32	Rogers 1992	Bangham	260			260	20
32	Rogers 1992	Bendix	210			140	20
32	Rogers 1992	Big Walnut Preserve--Heron	310			230	20
32	Rogers 1992	Blacklick	140			110	20
32	Rogers 1992	Cedar Lake	300			300	20

(Table 10 continued on next page)

(Table 10 continued)

Map Key	Source/Date	Stand	Live Tree Density ≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X cm (#/ha)	Min Diam X (cm)
32	Rogers 1992	Cleveland	240			170	20
32	Rogers 1992	Diamond Lake	310			210	20
32	Rogers 1992	First	210			180	20
32	Rogers 1992	Fowler	220			200	20
32	Rogers 1992	Fuller	140			110	20
32	Rogers 1992	Henry	410			310	20
32	Rogers 1992	Hultz	140			110	20
32	Rogers 1992	Jericho	180			180	20
32	Rogers 1992	Kado-Lato	180			180	20
32	Rogers 1992	LaPorte	200			150	20
32	Rogers 1992	Limbeck	320			250	20
32	Rogers 1992	Logansport	200			150	20
32	Rogers 1992	Lyon	220			190	20
32	Rogers 1992	Manlove	510			220	20
32	Rogers 1992	Morgan	350			300	20
32	Rogers 1992	Nerstrand	400			260	20
32	Rogers 1992	Ogden	290			230	20
32	Rogers 1992	Richter	240			190	20
32	Rogers 1992	Rosbrugh	160			160	20
32	Rogers 1992	Rush	240			140	20
32	Rogers 1992	Russ (Newton)	260			210	20
32	Rogers 1992	Shades State Park--Trail 2	100			70	20
32	Rogers 1992	Shades State Park--Trail 5	140			120	20
32	Rogers 1992	Taylor	370			270	20
32	Rogers 1992	Toumey	230			150	20
32	Rogers 1992	Tschantz	140			90	20
32	Rogers 1992	Warren	340			130	20
32	Rogers 1992	Waupun	220			170	20
32	Rogers 1992	Weaver	280			210	20
32	Rogers 1992	Wolsfeld	530			350	20
33	Runkle 1982	Hueston					
34	Runkle et al. 1984	Hueston	325	42	17	209	20
35	Schmelz 1964	Logansport	182				
35	Schmelz 1964	Pine Hills	254				
35	Schmelz 1964	Pioneer Mothers	324				
35	Schmelz 1964	Rosbrugh	177				
35	Schmelz 1964	Warren	244				

(Table 10 continued on next page)

(Table 10 continued)

			Live Tree Density				
Map Key	**Source/Date**	**Stand**	**≥10 cm (#/ha)**	**≥50 cm (#/ha)**	**≥70 cm (#/ha)**	**≥X cm (#/ha)**	**Min Diam X (cm)**
36	Schneider 1963	Toumey				1385	2.5
37	Spetich et al. 1996	Engelmann Woods				4500	2
37	Spetich et al. 1996	Spitler Woods				3700	2
38	Stai and Mladenoff 1993	Bowstring Lake	470	60	20		
38	Stai and Mladenoff 1993	Ludwig Management Area	570	0	0		
38	Stai and Mladenoff 1993	Moose Mountain Scientific and Natural Area	590	20	10		
38	Stai and Mladenoff 1993	Mt. Trudee	530	10	0		
38	Stai and Mladenoff 1993	New Dosey	640	0	0		
38	Stai and Mladenoff 1993	Nipisiquit Lake	580	0	0		
38	Stai and Mladenoff 1993	Prairie River	420	10	0		
38	Stai and Mladenoff 1993	Savanna Prairie	500	30	0		
38	Stai and Mladenoff 1993	Soo Line Railroad	530	30	0		
38	Stai and Mladenoff 1993	Spring Beauty Scientific and Natural Area	540	40	0		
38	Stai and Mladenoff 1993	Tom Lake	490	0	0		
39	Stearns 1956	Versailles State Park--Potzger	301				
40	Sudia 1960	Blacklick	305				
41	Thompson 1991	Plagge Woods	239				
42	Tyrrell 1988d	Hunt Hill	462	30		247	20
43	Woods 1979	Warren		81	31	131	20

[1] Value given is for trees >75 cm d.b.h.

Table 11.—*Basal area of live trees ≥10, ≥50, ≥70 cm for beech-maple-basswood old-growth study sites. For other minimum sizes, the basal area is listed under "≥X cm", with the minimum size for tallying trees given as "Min Diam X (cm)".*

			Live Tree Basal Area (BA)				
Map Key	**Source/Date**	**Stand**	**≥10 cm (m^2/ha)**	**≥50 cm (m^2/ha)**	**≥70 cm (m^2/ha)**	**≥X cm (m^2/ha)**	**Min Diam X (cm)**
1	Abrell and Jackson 1977	Hoot	28.1				
2	Aikman and Smelser 1938	North Woods Tract					
3	Aughanbaugh 1964	Crall					
4	Brisson et al. 1992	Muir's					
5	Bryant 1987	Winton	28.9				
6	Buell and Bormann 1955	Ponemah Point	30.4				
7	Cain 1935	Warren				51.8	2.5
8	Cho and Boerner 1991a	Goll					
8	Cho and Boerner 1991a	Sears/Carmean					
9	Cho and Boerner 1991b	Sears/Carmean	39.5				
10	Daubenmire 1936	Minnetonka	37.5				
10	Daubenmire 1936	Northfield	42.0				
11	Eggler 1938	East	54.3				
11	Eggler 1938	Hunt Hill	34.3				
11	Eggler 1938	Long Lake	37.3				
12	Esten 1932	Turkey Run State Park--Rocky Hollow					
13	Hale 1996	11 forests in Minnesota	30.0				
13	Hale 1996	Bello	28.7				
13	Hale 1996	Big Island	14.4				
13	Hale 1996	Dinosaur Island	28.8				
13	Hale 1996	Lowry Woods	28.5				
13	Hale 1996	Richardson	29.8				
13	Hale 1996	St. Charl-dog	30.4				
13	Hale 1996	Sugarbush	26.6				
13	Hale 1996	Taylor Woods	51.2				
13	Hale 1996	Townsend	34.6				
13	Hale 1996	Wolsfeld--old growth	37.2				
13	Hale 1996	Wray	24.7				
14	Jackson and Abrell 1977	Hoot					
15	Jackson and Allen 1967	Hoot	27.5				
16	Jackson and Allen 1969	Versailles State Park--Jackson	25.6				
16	Jackson and Allen 1969	Versailles State Park--Potzger	26.8				
17	Kucera and McDermott 1955	Douglas	40.7				
17	Kucera and McDermott 1955	Schnabel	52.4				
18	Lafer and Wistendahl 1970	Dysart North	45.9				
18	Lafer and Wistendahl 1970	Dysart South	62.0				
19	Landaal 1986	Schmidt	35.2				

(Table 11 continued on next page)

(Table 11 continued)

Map Key	Source/Date	Stand	Live Tree Basal Area (BA) ≥10 cm (m²/ha)	≥50 cm (m²/ha)	≥70 cm (m²/ha)	≥X cm (m²/ha)	Min Diam X (cm)
20	Leitner 1988a	Haskell Noyes Memorial Woods	38.8				
21	Leitner 1988b	Kewaskum Maple - Oak Woods	37.8				
22	Leitner 1988c	Renak - Polak Maple - Beech Woods	28.9				
23	Leitner 1988e	Waupun Park Maple Forest	31.9				
24	Leitner 1989b	Kurtz Woods	27.3				
25	Lindsey et al. 1961	Logansport	23.2				
26	Lindsey et al. 1969	Allee	29.4				
26	Lindsey et al. 1969	Bendix	28.2				
26	Lindsey et al. 1969	Casters	25.5				
26	Lindsey et al. 1969	Kado-Lato					
26	Lindsey et al. 1969	LaPorte--South	29.3				
26	Lindsey et al. 1969	Manlove	28.7				
26	Lindsey et al. 1969	Meltzer--upland site; Crosby soil	28.9				
26	Lindsey et al. 1969	Officers' Woods North	25.8				
26	Lindsey et al. 1969	Ogden					
26	Lindsey et al. 1969	Rosbrugh	25.3				
26	Lindsey et al. 1969	Turkey Run State Park--Rocky Hollow	25.9				
26	Lindsey et al. 1969	Weaver	27.4				
27	Pell and Mack 1977	Ansell's Ledge					
27	Pell and Mack 1977	Bole					
27	Pell and Mack 1977	Crall					
27	Pell and Mack 1977	Firestone					
27	Pell and Mack 1977	Fowler					
27	Pell and Mack 1977	Graber					
27	Pell and Mack 1977	Holden Arboretum					
27	Pell and Mack 1977	Kimball					
27	Pell and Mack 1977	Tinker's Creek					
27	Pell and Mack 1977	Williams					
28	Petty and Harwood 1964	Rush	15.3				
29	Petty and Lindsey 1962	Hoot	31.2[1]				
30	Potzger and Friesner 1943	Berkey				55.3	2.5
31	Riemenschneider and Blodgett 1983	Bendix	25.7			26.7	4.0
32	Rogers 1992	Bangham	31.7				
32	Rogers 1992	Bendix	25.2				
32	Rogers 1992	Big Walnut Preserve--Heron	37.8				
32	Rogers 1992	Blacklick	34.7				
32	Rogers 1992	Cedar Lake	57.3				

(Table 11 continued on next page)

(Table 11 continued)

			Live Tree Basal Area (BA)				
Map Key	Source/Date	Stand	≥10 cm (m^2/ha)	≥50 cm (m^2/ha)	≥70 cm (m^2/ha)	≥X cm (m^2/ha)	Min Diam X (cm)
32	Rogers 1992	Cleveland	36.2				
32	Rogers 1992	Diamond Lake	48.3				
32	Rogers 1992	First	48.3				
32	Rogers 1992	Fowler	48.0				
32	Rogers 1992	Fuller	27.9				
32	Rogers 1992	Henry	42.6				
32	Rogers 1992	Hultz	30.3				
32	Rogers 1992	Jericho	45.8				
32	Rogers 1992	Kado-Lato	28.2				
32	Rogers 1992	LaPorte	29.0				
32	Rogers 1992	Limbeck	39.9				
32	Rogers 1992	Logansport	33.2				
32	Rogers 1992	Lyon	33.4				
32	Rogers 1992	Manlove	28.7				
32	Rogers 1992	Morgan	60.8				
32	Rogers 1992	Nerstrand	45.5				
32	Rogers 1992	Ogden	35.1				
32	Rogers 1992	Richter	69.1				
32	Rogers 1992	Rosbrugh	23.7				
32	Rogers 1992	Rush	34.9				
32	Rogers 1992	Russ (Newton)	43.4				
32	Rogers 1992	Shades State Park--Trail 2	21.2				
32	Rogers 1992	Shades State Park--Trail 5	31.8				
32	Rogers 1992	Taylor	56.1				
32	Rogers 1992	Toumey	40.6				
32	Rogers 1992	Tschantz	32.6				
32	Rogers 1992	Warren	36.6				
32	Rogers 1992	Waupun	27.7				
32	Rogers 1992	Weaver	26.9				
32	Rogers 1992	Wolsfeld	45.4				
33	Runkle 1982	Hueston					
34	Runkle et al. 1984	Hueston	32.0				
35	Schmelz 1964	Logansport	22.4				
35	Schmelz 1964	Pine Hills	26.3				
35	Schmelz 1964	Pioneer Mothers	27.1				
35	Schmelz 1964	Rosbrugh	26.1				
35	Schmelz 1964	Warren	28.3				

(Table 11 continued on next page)

(Table 11 continued)

Map Key	Source/Date	Stand	Live Tree Basal Area (BA) ≥10 cm (m²/ha)	≥50 cm (m²/ha)	≥70 cm (m²/ha)	≥X cm (m²/ha)	Min Diam X (cm)
36	Schneider 1963	Toumey				31.6	2.5
37	Spetich et al. 1996	Engelmann Woods				24.2	2.0
37	Spetich et al. 1996	Spitler Woods				30.4	2.0
38	Stai and Mladenoff 1993	Bowstring Lake	37.9	20.5	10.0		
38	Stai and Mladenoff 1993	Ludwig Management Area	30.4	0	0		
38	Stai and Mladenoff 1993	Moose Mountain Scientific and Natural Area	30.2	6.4	3.9		
38	Stai and Mladenoff 1993	Mt. Trudee	34.5	2.4	0		
38	Stai and Mladenoff 1993	New Dosey	29.8	0	0		
38	Stai and Mladenoff 1993	Nipisiquit Lake	25.2	0	0		
38	Stai and Mladenoff 1993	Prairie River	29.8	2.1	0		
38	Stai and Mladenoff 1993	Savanna Prairie	27.4	6.2	0		
38	Stai and Mladenoff 1993	Soo Line Railroad	35.0	8.2	0		
38	Stai and Mladenoff 1993	Spring Beauty Scientific and Natural Area	31.6	10.4	0		
38	Stai and Mladenoff 1993	Tom Lake	21.9	0	0		
39	Stearns 1956	Versailles State Park--Potzger	36.8				
40	Sudia 1960	Blacklick	29.1				
41	Thompson 1991	Plagge Woods	17.0				
42	Tyrrell 1988d	Hunt Hill	32.9				
43	Woods 1979	Warren					

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[1] When Lindsey et al. (1969) cited this study they gave the basal area as 25.3 m²/ha.

Table 12.—*Average tree age by species for beech-maple-basswood old-growth study sites.*

			Average Tree Age (yr)				
Map Key	Source/Date	Stand	Sugar Maple	American Beech	American Basswood	Northern Red Oak	Other
1	Abrell and Jackson 1977	Hoot					
2	Aikman and Smelser 1938	North Woods Tract					
3	Aughanbaugh 1964	Crall					
4	Brisson et al. 1992	Muir's	302+ [1]	250 [1]			
5	Bryant 1987	Winton					
6	Buell and Bormann 1955	Ponemah Point					
7	Cain 1935	Warren					
8	Cho and Boerner 1991a	Goll					
8	Cho and Boerner 1991a	Sears/Carmean					
9	Cho and Boerner 1991b	Sears/Carmean					
10	Daubenmire 1936	Minnetonka					
10	Daubenmire 1936	Northfield					
11	Eggler 1938	East					
11	Eggler 1938	Hunt Hill	215		125	95	
11	Eggler 1938	Long Lake					
12	Esten 1932	Turkey Run State Park--Rocky Hollow					
13	Hale 1996	11 forests in Minnesota					
13	Hale 1996	Bello					124 [2]
13	Hale 1996	Big Island					134 [2]
13	Hale 1996	Dinosaur Island					136 [2]
13	Hale 1996	Lowry Woods					172 [2]
13	Hale 1996	Richardson					152 [2]
13	Hale 1996	St. Charl-dog					128 [2]
13	Hale 1996	Sugarbush					157 [2]
13	Hale 1996	Taylor Woods					164 [2]
13	Hale 1996	Townsend					138 [2]
13	Hale 1996	Wolsfeld--old growth					154 [2]
13	Hale 1996	Wray					161 [2]
14	Jackson and Abrell 1977	Hoot					
15	Jackson and Allen 1967	Hoot					
16	Jackson and Allen 1969	Versailles State Park--Jackson					
16	Jackson and Allen 1969	Versailles State Park--Potzger					
17	Kucera and McDermott 1955	Douglas					
17	Kucera and McDermott 1955	Schnabel					
18	Lafer and Wistendahl 1970	Dysart North					
18	Lafer and Wistendahl 1970	Dysart South					
19	Landaal 1986	Schmidt					

(Table 12 continued on next page)

(Table 12 continued)

Map Key	Source/Date	Stand	Average Tree Age (yr)				
			Sugar Maple	American Beech	American Basswood	Northern Red Oak	Other
20	Leitner 1988a	Haskell Noyes Memorial Woods					
21	Leitner 1988b	Kewaskum Maple - Oak Woods					
22	Leitner 1988c	Renak - Polak Maple - Beech Woods					
23	Leitner 1988e	Waupun Park Maple Forest					
24	Leitner 1989b	Kurtz Woods					
25	Lindsey et al. 1961	Logansport					
26	Lindsey et al. 1969	Allee					
26	Lindsey et al. 1969	Bendix					
26	Lindsey et al. 1969	Casters					
26	Lindsey et al. 1969	Kado-Lato					
26	Lindsey et al. 1969	LaPorte--South					
26	Lindsey et al. 1969	Manlove					
26	Lindsey et al. 1969	Meltzer--upland site; Crosby soil					
26	Lindsey et al. 1969	Officers' Woods North					
26	Lindsey et al. 1969	Ogden					
26	Lindsey et al. 1969	Rosbrugh					
26	Lindsey et al. 1969	Turkey Run State Park--Rocky Hollow					
26	Lindsey et al. 1969	Weaver					
27	Pell and Mack 1977	Ansell's Ledge					
27	Pell and Mack 1977	Bole					
27	Pell and Mack 1977	Crall					
27	Pell and Mack 1977	Firestone					
27	Pell and Mack 1977	Fowler					
27	Pell and Mack 1977	Graber					
27	Pell and Mack 1977	Holden Arboretum					
27	Pell and Mack 1977	Kimball					
27	Pell and Mack 1977	Tinker's Creek					
27	Pell and Mack 1977	Williams					
28	Petty and Harwood 1964	Rush					
29	Petty and Lindsey 1962	Hoot					
30	Potzger and Friesner 1943	Berkey					
31	Riemenschneider and Blodgett 1983	Bendix					
32	Rogers 1992	Bangham					
32	Rogers 1992	Bendix					
32	Rogers 1992	Big Walnut Preserve--Heron					
32	Rogers 1992	Blacklick					
32	Rogers 1992	Cedar Lake					

(Table 12 continued on next page)

(Table 12 continued)

Map Key	Source/Date	Stand	Average Tree Age (yr) Sugar Maple	American Beech	American Basswood	Northern Red Oak	Other
32	Rogers 1992	Cleveland					
32	Rogers 1992	Diamond Lake					
32	Rogers 1992	First					
32	Rogers 1992	Fowler					
32	Rogers 1992	Fuller					
32	Rogers 1992	Henry					
32	Rogers 1992	Hultz					
32	Rogers 1992	Jericho					
32	Rogers 1992	Kado-Lato					
32	Rogers 1992	LaPorte					
32	Rogers 1992	Limbeck					
32	Rogers 1992	Logansport					
32	Rogers 1992	Lyon					
32	Rogers 1992	Manlove					
32	Rogers 1992	Morgan					
32	Rogers 1992	Nerstrand					
32	Rogers 1992	Ogden					
32	Rogers 1992	Richter					
32	Rogers 1992	Rosbrugh					
32	Rogers 1992	Rush					
32	Rogers 1992	Russ (Newton)					
32	Rogers 1992	Shades State Park--Trail 2					
32	Rogers 1992	Shades State Park--Trail 5					
32	Rogers 1992	Taylor					
32	Rogers 1992	Toumey					
32	Rogers 1992	Tschantz					
32	Rogers 1992	Warren					
32	Rogers 1992	Waupun					
32	Rogers 1992	Weaver					
32	Rogers 1992	Wolsfeld					
33	Runkle 1982	Hueston					
34	Runkle et al. 1984	Hueston					
35	Schmelz 1964	Logansport					
35	Schmelz 1964	Pine Hills					
35	Schmelz 1964	Pioneer Mothers					
35	Schmelz 1964	Rosbrugh					
35	Schmelz 1964	Warren					

(Table 12 continued on next page)

(Table 12 continued)

Map Key	Source/Date	Stand	Average Tree Age (yr)				
			Sugar Maple	American Beech	American Basswood	Northern Red Oak	Other
36	Schneider 1963	Toumey	237	290	117	106	235 [3]
37	Spetich et al. 1996	Engelmann Woods					
37	Spetich et al. 1996	Spitler Woods					
38	Stai and Mladenoff 1993	Bowstring Lake	133		127		
38	Stai and Mladenoff 1993	Ludwig Management Area	192		63		
38	Stai and Mladenoff 1993	Moose Mountain Scientific and Natural Area	128		101		
38	Stai and Mladenoff 1993	Mt. Trudee	136				
38	Stai and Mladenoff 1993	New Dosey	150		124		
38	Stai and Mladenoff 1993	Nipisiquit Lake	125				
38	Stai and Mladenoff 1993	Prairie River	184		168		
38	Stai and Mladenoff 1993	Savanna Prairie	77		124		
38	Stai and Mladenoff 1993	Soo Line Railroad	197		187		
38	Stai and Mladenoff 1993	Spring Beauty Scientific and Natural Area	171				
38	Stai and Mladenoff 1993	Tom Lake	149				
39	Stearns 1956	Versailles State Park--Potzger					
40	Sudia 1960	Blacklick					
41	Thompson 1991	Plagge Woods					
42	Tyrrell 1988d	Hunt Hill				124 [4]	
43	Woods 1979	Warren					

[1] Age-structure data presented.

[2] Average of 5 oldest of 10 trees cored in or near sample plot.

[3] Elm

[4] Age information collected in 1994 (Tyrrell unpublished data).

Table 13.—*Maximum tree diameter by species, average canopy height, and percentage of the tree canopy in gaps for beech-maple-basswood old-growth study sites.*

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm) Sugar Maple	American Beech	American Basswood	Elm	Yellow-Poplar	Northern Red Oak	Average Canopy Height (m)	Canopy Gaps (%)
1	Abrell and Jackson 1977	Hoot								
2	Aikman and Smelser 1938	North Woods Tract	56		41	30			23	
3	Aughanbaugh 1964	Crall			127	107	102	102	32	
4	Brisson et al. 1992	Muir's	88	75	80	63				
5	Bryant 1987	Winton								
6	Buell and Bormann 1955	Ponemah Point	44		76				17	4.0
7	Cain 1935	Warren							34	
8	Cho and Boerner 1991a	Goll	65	85	95					2.8
8	Cho and Boerner 1991a	Sears/Carmean	45	65	55	45		75		2.6
9	Cho and Boerner 1991b	Sears/Carmean								
10	Daubenmire 1936	Minnetonka	74		76	104		81		
10	Daubenmire 1936	Northfield								
11	Eggler 1938	East								
11	Eggler 1938	Hunt Hill								
11	Eggler 1938	Long Lake								
12	Esten 1932	Turkey Run State Park--Rocky Hollow								
13	Hale 1996	11 forests in Minnesota								
13	Hale 1996	Bello								
13	Hale 1996	Big Island								
13	Hale 1996	Dinosaur Island								
13	Hale 1996	Lowry Woods								
13	Hale 1996	Richardson								
13	Hale 1996	St. Charl-dog								
13	Hale 1996	Sugarbush								
13	Hale 1996	Taylor Woods								
13	Hale 1996	Townsend								
13	Hale 1996	Wolsfeld--old growth								
13	Hale 1996	Wray								
14	Jackson and Abrell 1977	Hoot								
15	Jackson and Allen 1967	Hoot								
16	Jackson and Allen 1969	Versailles State Park--Jackson		101			93	89	36	
16	Jackson and Allen 1969	Versailles State Park--Potzger	82	116	65		89		34	
17	Kucera and McDermott 1955	Douglas			90					
17	Kucera and McDermott 1955	Schnabel								
18	Lafer and Wistendahl 1970	Dysart North								
18	Lafer and Wistendahl 1970	Dysart South								
19	Landaal 1986	Schmidt	85		55	75		65		

(Table 13 continued on next page)

(Table 13 continued)

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm) Sugar Maple	American Beech	American Basswood	Elm	Yellow-Poplar	Northern Red Oak	Average Canopy Height (m)	Canopy Gaps (%)
20	Leitner 1988a	Haskell Noyes Memorial Woods								
21	Leitner 1988b	Kewaskum Maple - Oak Woods	>50		>50			>75		
22	Leitner 1988c	Renak - Polak Maple - Beech Woods	>50	>50	>50	>50		>75		
23	Leitner 1988e	Waupun Park Maple Forest	>75		>50			>75		
24	Leitner 1989b	Kurtz Woods	>50	>50	>75					
25	Lindsey et al. 1961	Logansport	61	63		71				
26	Lindsey et al. 1969	Allee								
26	Lindsey et al. 1969	Bendix								
26	Lindsey et al. 1969	Casters								
26	Lindsey et al. 1969	Kado-Lato	87				74	83		
26	Lindsey et al. 1969	LaPorte--South								
26	Lindsey et al. 1969	Manlove					158			
26	Lindsey et al. 1969	Meltzer--upland site; Crosby soil		76		86	86	97		
26	Lindsey et al. 1969	Officers' Woods North								
26	Lindsey et al. 1969	Ogden	97	87			96	81		
26	Lindsey et al. 1969	Rosbrugh	89	88				119		
26	Lindsey et al. 1969	Turkey Run State Park--Rocky Hollow								
26	Lindsey et al. 1969	Weaver								
27	Pell and Mack 1977	Ansell's Ledge								
27	Pell and Mack 1977	Bole								
27	Pell and Mack 1977	Crall								
27	Pell and Mack 1977	Firestone								
27	Pell and Mack 1977	Fowler								
27	Pell and Mack 1977	Graber								
27	Pell and Mack 1977	Holden Arboretum								
27	Pell and Mack 1977	Kimball								
27	Pell and Mack 1977	Tinker's Creek								
27	Pell and Mack 1977	Williams								
28	Petty and Harwood 1964	Rush	56	86	56	56	66	76		
29	Petty and Lindsey 1962	Hoot	89	89		66	104	58	37	
30	Potzger and Friesner 1943	Berkey				124	124			
31	Riemenschneider and Blodgett 1983	Bendix		105						
32	Rogers 1992	Bangham	49	66	34			61		
32	Rogers 1992	Bendix								
32	Rogers 1992	Big Walnut Preserve--Heron	82	82			69	80		
32	Rogers 1992	Blacklick	84	93		27				
32	Rogers 1992	Cedar Lake	66			112		67		

(Table 13 continued on next page)

(Table 13 continued)

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm): Sugar Maple	American Beech	American Basswood	Elm	Yellow-Poplar	Northern Red Oak	Average Canopy Height (m)	Canopy Gaps (%)
32	Rogers 1992	Cleveland	74	67						
32	Rogers 1992	Diamond Lake	96		87	128		65		
32	Rogers 1992	First	85	104	80		87			
32	Rogers 1992	Fowler	70	73	55		58			
32	Rogers 1992	Fuller	73	82		53				
32	Rogers 1992	Henry	65		88	70		70		
32	Rogers 1992	Hultz	101	89		29	71			
32	Rogers 1992	Jericho	71	45	72	37		92		
32	Rogers 1992	Kado-Lato								
32	Rogers 1992	LaPorte								
32	Rogers 1992	Limbeck	58		66	72		64		
32	Rogers 1992	Logansport	71	78		19				
32	Rogers 1992	Lyon	75	77	64					
32	Rogers 1992	Manlove								
32	Rogers 1992	Morgan	78	37	96					
32	Rogers 1992	Nerstrand	48		56			45		
32	Rogers 1992	Ogden	97	87			96	81		
32	Rogers 1992	Richter	66		81	91				
32	Rogers 1992	Rosbrugh	91	88				119		
32	Rogers 1992	Rush	31	90	97	64	59			
32	Rogers 1992	Russ (Newton)	71		97	39				
32	Rogers 1992	Shades State Park--Trail 2	78	96	53	76	29			
32	Rogers 1992	Shades State Park--Trail 5								
32	Rogers 1992	Taylor	53		66	99		82		
32	Rogers 1992	Toumey	73	99	75			127		
32	Rogers 1992	Tschantz	84	101		42		73		
32	Rogers 1992	Warren	87	112	11					
32	Rogers 1992	Waupun	68			11				
32	Rogers 1992	Weaver								
32	Rogers 1992	Wolsfeld	35		67	68		48		
33	Runkle 1982	Hueston								7.0[1]
34	Runkle et al. 1984	Hueston	95	115		15	55			7.0
35	Schmelz 1964	Logansport								
35	Schmelz 1964	Pine Hills								
35	Schmelz 1964	Pioneer Mothers								
35	Schmelz 1964	Rosbrugh								
35	Schmelz 1964	Warren								

(Table 13 continued on next page)

(Table 13 continued)

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm) Sugar Maple	American Beech	American Basswood	Elm	Yellow-Poplar	Northern Red Oak	Average Canopy Height (m)	Canopy Gaps (%)
36	Schneider 1963	Toumey	94	102	97	91		114		
37	Spetich et al. 1996	Engelmann Woods								
37	Spetich et al. 1996	Spitler Woods								
38	Stai and Mladenoff 1993	Bowstring Lake	76		84					
38	Stai and Mladenoff 1993	Ludwig Management Area	49		49					
38	Stai and Mladenoff 1993	Moose Mountain Scientific and Natural Area	71		33					
38	Stai and Mladenoff 1993	Mt. Trudee	46		55					
38	Stai and Mladenoff 1993	New Dosey	46		43					
38	Stai and Mladenoff 1993	Nipisiquit Lake	47		40					
38	Stai and Mladenoff 1993	Prairie River	44		49					
38	Stai and Mladenoff 1993	Savanna Prairie	50		53					
38	Stai and Mladenoff 1993	Soo Line Railroad	69		53					
38	Stai and Mladenoff 1993	Spring Beauty Scientific and Natural Area	60							
38	Stai and Mladenoff 1993	Tom Lake	37							
39	Stearns 1956	Versailles State Park--Potzger								
40	Sudia 1960	Blacklick								
41	Thompson 1991	Plagge Woods						>50		
42	Tyrrell 1988d	Hunt Hill	58		49			64		
43	Woods 1979	Warren								

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[1] Canopy gap data listed also in Runkle (1990) and Runkle et al. (1984).

Table 14.—*Density, volume, and minimum diameter measured for standing dead trees (snags) for beech-maple-basswood old-growth study sites.*

			Standing Dead Trees (Snags)		
Map Key	Source/Date	Stand	Snag Density (#/ha)	Snag Volume (m^3/ha)	Min Snag Diam (cm)
1	Abrell and Jackson 1977	Hoot	[1]		
2	Aikman and Smelser 1938	North Woods Tract			
3	Aughanbaugh 1964	Crall			
4	Brisson et al. 1992	Muir's			
5	Bryant 1987	Winton			
6	Buell and Bormann 1955	Ponemah Point			
7	Cain 1935	Warren			
8	Cho and Boerner 1991a	Goll			
8	Cho and Boerner 1991a	Sears/Carmean			
9	Cho and Boerner 1991b	Sears/Carmean			
10	Daubenmire 1936	Minnetonka			
10	Daubenmire 1936	Northfield			
11	Eggler 1938	East			
11	Eggler 1938	Hunt Hill			
11	Eggler 1938	Long Lake			
12	Esten 1932	Turkey Run State Park--Rocky Hollow			
13	Hale 1996	11 forests in Minnesota	33	26.7	10
13	Hale 1996	Bello	25	24.5	10
13	Hale 1996	Big Island	38	21.2	10
13	Hale 1996	Dinosaur Island	38	12.4	10
13	Hale 1996	Lowry Woods	63	25.2	10
13	Hale 1996	Richardson	38	11.0	10
13	Hale 1996	St. Charl-dog	0	0	10
13	Hale 1996	Sugarbush	75	78.7	10
13	Hale 1996	Taylor Woods	13	5.9	10
13	Hale 1996	Townsend	38	49.7	10
13	Hale 1996	Wolsfeld--old growth	38	64.8	10
13	Hale 1996	Wray	0	0	10
14	Jackson and Abrell 1977	Hoot	[1]		
15	Jackson and Allen 1967	Hoot			
16	Jackson and Allen 1969	Versailles State Park--Jackson			
16	Jackson and Allen 1969	Versailles State Park--Potzger			
17	Kucera and McDermott 1955	Douglas			
17	Kucera and McDermott 1955	Schnabel			
18	Lafer and Wistendahl 1970	Dysart North			
18	Lafer and Wistendahl 1970	Dysart South			
19	Landaal 1986	Schmidt			

(Table 14 continued on next page)

(Table 14 continued)

Map Key	Source/Date	Stand	Standing Dead Trees (Snags) Snag Density (#/ha)	Snag Volume (m^3/ha)	Min Snag Diam (cm)
20	Leitner 1988a	Haskell Noyes Memorial Woods	22	[2]	10
21	Leitner 1988b	Kewaskum Maple - Oak Woods	40	[3]	10
22	Leitner 1988c	Renak - Polak Maple - Beech Woods	32	[3]	10
23	Leitner 1988e	Waupun Park Maple Forest	28	[3]	10
24	Leitner 1989b	Kurtz Woods	56	[3]	10
25	Lindsey et al. 1961	Logansport			
26	Lindsey et al. 1969	Allee			
26	Lindsey et al. 1969	Bendix			
26	Lindsey et al. 1969	Casters			
26	Lindsey et al. 1969	Kado-Lato			
26	Lindsey et al. 1969	LaPorte--South			
26	Lindsey et al. 1969	Manlove			
26	Lindsey et al. 1969	Meltzer--upland site; Crosby soil			
26	Lindsey et al. 1969	Officers' Woods North			
26	Lindsey et al. 1969	Ogden			
26	Lindsey et al. 1969	Rosbrugh			
26	Lindsey et al. 1969	Turkey Run State Park--Rocky Hollow			
26	Lindsey et al. 1969	Weaver			
27	Pell and Mack 1977	Ansell's Ledge			
27	Pell and Mack 1977	Bole			
27	Pell and Mack 1977	Crall			
27	Pell and Mack 1977	Firestone			
27	Pell and Mack 1977	Fowler			
27	Pell and Mack 1977	Graber			
27	Pell and Mack 1977	Holden Arboretum			
27	Pell and Mack 1977	Kimball			
27	Pell and Mack 1977	Tinker's Creek			
27	Pell and Mack 1977	Williams			
28	Petty and Harwood 1964	Rush			
29	Petty and Lindsey 1962	Hoot			
30	Potzger and Friesner 1943	Berkey			
31	Riemenschneider and Blodgett 1983	Bendix			
32	Rogers 1992	Bangham			
32	Rogers 1992	Bendix			
32	Rogers 1992	Big Walnut Preserve--Heron			
32	Rogers 1992	Blacklick			
32	Rogers 1992	Cedar Lake			

(Table 14 continued on next page)

(Table 14 continued)

Map Key	Source/Date	Stand	Standing Dead Trees (Snags) Snag Density (#/ha)	Snag Volume (m^3/ha)	Min Snag Diam (cm)
32	Rogers 1992	Cleveland			
32	Rogers 1992	Diamond Lake			
32	Rogers 1992	First			
32	Rogers 1992	Fowler			
32	Rogers 1992	Fuller			
32	Rogers 1992	Henry			
32	Rogers 1992	Hultz			
32	Rogers 1992	Jericho			
32	Rogers 1992	Kado-Lato			
32	Rogers 1992	LaPorte			
32	Rogers 1992	Limbeck			
32	Rogers 1992	Logansport			
32	Rogers 1992	Lyon			
32	Rogers 1992	Manlove			
32	Rogers 1992	Morgan			
32	Rogers 1992	Nerstrand			
32	Rogers 1992	Ogden			
32	Rogers 1992	Richter			
32	Rogers 1992	Rosbrugh			
32	Rogers 1992	Rush			
32	Rogers 1992	Russ (Newton)			
32	Rogers 1992	Shades State Park--Trail 2			
32	Rogers 1992	Shades State Park--Trail 5			
32	Rogers 1992	Taylor			
32	Rogers 1992	Toumey			
32	Rogers 1992	Tschantz			
32	Rogers 1992	Warren			
32	Rogers 1992	Waupun			
32	Rogers 1992	Weaver			
32	Rogers 1992	Wolsfeld			
33	Runkle 1982	Hueston			
34	Runkle et al. 1984	Hueston			
35	Schmelz 1964	Logansport			
35	Schmelz 1964	Pine Hills			
35	Schmelz 1964	Pioneer Mothers			
35	Schmelz 1964	Rosbrugh			
35	Schmelz 1964	Warren			

(Table 14 continued on next page)

(Table 14 continued)

Map Key	Source/Date	Stand	Standing Dead Trees (Snags) Snag Density (#/ha)	Snag Volume (m^3/ha)	Min Snag Diam (cm)
36	Schneider 1963	Toumey	[4]		
37	Spetich et al. 1996	Engelmann Woods	131		2
37	Spetich et al. 1996	Spitler Woods	99		2
38	Stai and Mladenoff 1993	Bowstring Lake	20 [5]	7.0 [5]	10/15 [6]
38	Stai and Mladenoff 1993	Ludwig Management Area	20 [7]	13.6 [7]	10/15 [9]
38	Stai and Mladenoff 1993	Moose Mountain Scientific and Natural Area	70 [8]	31.2 [8]	10/15 [9]
38	Stai and Mladenoff 1993	Mt. Trudee	30 [9]	13.5 [9]	10/15 [9]
38	Stai and Mladenoff 1993	New Dosey	20 [10]	1.3 [10]	10/15 [9]
38	Stai and Mladenoff 1993	Nipisiquit Lake	100 [11]	44.8 [11]	10/15 [9]
38	Stai and Mladenoff 1993	Prairie River	30 [12]	6.0 [12]	10/15 [9]
38	Stai and Mladenoff 1993	Savanna Prairie	50 [13]	2.8 [13]	10/15 [9]
38	Stai and Mladenoff 1993	Soo Line Railroad	50 [14]	0.9 [14]	10/15 [9]
38	Stai and Mladenoff 1993	Spring Beauty Scientific and Natural Area	40 [15]	17.4 [15]	10/15 [9]
38	Stai and Mladenoff 1993	Tom Lake	80 [16]	28.1 [16]	10/15 [9]
39	Stearns 1956	Versailles State Park--Potzger			
40	Sudia 1960	Blacklick			
41	Thompson 1991	Plagge Woods	26		10
42	Tyrrell 1988d	Hunt Hill	173	[17]	10
43	Woods 1979	Warren			

[1] Mortality and ingrowth data presented.

[2] Basal area of dead standing trees = 1.8 m^2/ha.

[3] Basal area of dead standing trees = 2.0 m^2/ha.

[4] Mortality rates given.

[5] Density of snags for the dominant species only = 20; volume of snags for the dominant species only = 7.

[6] Minimum diameter of snags was 10 cm, of logs 15 cm.

[7] Density of snags for the dominant species only = 10; volume of snags for the dominant species only = 1.8.

[8] Density of snags for the dominant species only = 60; volume of snags for the dominant species only = 30.5.

[9] Density of snags for the dominant species only = 30; volume of snags for the dominant species only = 13.5.

[10] Density of snags for the dominant species only = 10; volume of snags for the dominant species only = 0.

[11] Density of snags for the dominant species only = 40; volume of snags for the dominant species only = 17.3.

[12] Density of snags for the dominant species only = 10; volume of snags for the dominant species only = 2.1.

[13] Density of snags for the dominant species only = 0; volume of snags for the dominant species only = 0.

[14] Density of snags for the dominant species only = 20; volume of snags for the dominant species only = 0.

[15] Density of snags for the dominant species only = 20; volume of snags for the dominant species only = 4.3.

[16] Density of snags for the dominant species only = 70; volume of snags for the dominant species only = 28.1.

[17] Snag basal area = 0.8 m^2/ha.

Table 15.—*Density, volume, and minimum diameter measured for fallen dead trees (logs) and total volume of coarse woody debris (snags and logs) for beech-maple-basswood old-growth study sites.*

			------------Fallen Dead Trees (Logs)------------			Total
Map Key	Source/Date	Stand	Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)	CWD Volume (m^3/ha)
1	Abrell and Jackson 1977	Hoot	[1]			
2	Aikman and Smelser 1938	North Woods Tract				
3	Aughanbaugh 1964	Crall				
4	Brisson et al. 1992	Muir's				
5	Bryant 1987	Winton				
6	Buell and Bormann 1955	Ponemah Point				
7	Cain 1935	Warren				
8	Cho and Boerner 1991a	Goll				
8	Cho and Boerner 1991a	Sears/Carmean				
9	Cho and Boerner 1991b	Sears/Carmean				
10	Daubenmire 1936	Minnetonka				
10	Daubenmire 1936	Northfield				
11	Eggler 1938	East				
11	Eggler 1938	Hunt Hill				
11	Eggler 1938	Long Lake				
12	Esten 1932	Turkey Run State Park--Rocky Hollow				
13	Hale 1996	11 forests in Minnesota	424	61.2 [2]	10	87.9
13	Hale 1996	Bello	463	121.3 [3]	10	145.8
13	Hale 1996	Big Island	438	36.3 [4]	10	57.5
13	Hale 1996	Dinosaur Island	413	51.9 [5]	10	64.3
13	Hale 1996	Lowry Woods	100	12.3 [6]	10	37.5
13	Hale 1996	Richardson	463	61.5 [7]	10	72.5
13	Hale 1996	St. Charl-dog	200	26.4 [8]	10	26.4
13	Hale 1996	Sugarbush	363	65.9 [9]	10	144.6
13	Hale 1996	Taylor Woods	563	92.9 [10]	10	98.8
13	Hale 1996	Townsend	538	40.4 [11]	10	90.1
13	Hale 1996	Wolsfeld--old growth	513	81.0 [12]	10	145.8
13	Hale 1996	Wray	613	84.0 [13]	10	84.0
14	Jackson and Abrell 1977	Hoot	[1]			
15	Jackson and Allen 1967	Hoot				
16	Jackson and Allen 1969	Versailles State Park--Jackson				
16	Jackson and Allen 1969	Versailles State Park--Potzger				
17	Kucera and McDermott 1955	Douglas				
17	Kucera and McDermott 1955	Schnabel				
18	Lafer and Wistendahl 1970	Dysart North				
18	Lafer and Wistendahl 1970	Dysart South				
19	Landaal 1986	Schmidt				

(Table 15 continued on next page)

(Table 15 continued)

Map Key	Source/Date	Stand	Fallen Dead Trees (Logs): Density of Logs (#/ha)	Fallen Dead Trees (Logs): Volume of Logs (m^3/ha)	Fallen Dead Trees (Logs): Min Diam Logs (cm)	Total CWD Volume (m^3/ha)
20	Leitner 1988a	Haskell Noyes Memorial Woods		[14]	30	
21	Leitner 1988b	Kewaskum Maple - Oak Woods		[15]	30	
22	Leitner 1988c	Renak - Polak Maple - Beech Woods		[16]	30	
23	Leitner 1988e	Waupun Park Maple Forest		[17]	30	
24	Leitner 1989b	Kurtz Woods		[18]	30	
25	Lindsey et al. 1961	Logansport				
26	Lindsey et al. 1969	Allee				
26	Lindsey et al. 1969	Bendix				
26	Lindsey et al. 1969	Casters				
26	Lindsey et al. 1969	Kado-Lato				
26	Lindsey et al. 1969	LaPorte--South				
26	Lindsey et al. 1969	Manlove				
26	Lindsey et al. 1969	Meltzer--upland site; Crosby soil				
26	Lindsey et al. 1969	Officers' Woods North				
26	Lindsey et al. 1969	Ogden				
26	Lindsey et al. 1969	Rosbrugh				
26	Lindsey et al. 1969	Turkey Run State Park--Rocky Hollow				
26	Lindsey et al. 1969	Weaver				
27	Pell and Mack 1977	Ansell's Ledge				
27	Pell and Mack 1977	Bole				
27	Pell and Mack 1977	Crall				
27	Pell and Mack 1977	Firestone				
27	Pell and Mack 1977	Fowler				
27	Pell and Mack 1977	Graber				
27	Pell and Mack 1977	Holden Arboretum				
27	Pell and Mack 1977	Kimball				
27	Pell and Mack 1977	Tinker's Creek				
27	Pell and Mack 1977	Williams				
28	Petty and Harwood 1964	Rush				
29	Petty and Lindsey 1962	Hoot				
30	Potzger and Friesner 1943	Berkey				
31	Riemenschneider and Blodgett 1	Bendix				
32	Rogers 1992	Bangham				
32	Rogers 1992	Bendix				
32	Rogers 1992	Big Walnut Preserve--Heron				
32	Rogers 1992	Blacklick				
32	Rogers 1992	Cedar Lake				

(Table 15 continued on next page)

(Table 15 continued)

Map Key	Source/Date	Stand	Fallen Dead Trees (Logs) Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)	Total CWD Volume (m^3/ha)
32	Rogers 1992	Cleveland				
32	Rogers 1992	Diamond Lake				
32	Rogers 1992	First				
32	Rogers 1992	Fowler				
32	Rogers 1992	Fuller				
32	Rogers 1992	Henry				
32	Rogers 1992	Hultz				
32	Rogers 1992	Jericho				
32	Rogers 1992	Kado-Lato				
32	Rogers 1992	LaPorte				
32	Rogers 1992	Limbeck				
32	Rogers 1992	Logansport				
32	Rogers 1992	Lyon				
32	Rogers 1992	Manlove				
32	Rogers 1992	Morgan				
32	Rogers 1992	Nerstrand				
32	Rogers 1992	Ogden				
32	Rogers 1992	Richter				
32	Rogers 1992	Rosbrugh				
32	Rogers 1992	Rush				
32	Rogers 1992	Russ (Newton)				
32	Rogers 1992	Shades State Park--Trail 2				
32	Rogers 1992	Shades State Park--Trail 5				
32	Rogers 1992	Taylor				
32	Rogers 1992	Toumey				
32	Rogers 1992	Tschantz				
32	Rogers 1992	Warren				
32	Rogers 1992	Waupun				
32	Rogers 1992	Weaver				
32	Rogers 1992	Wolsfeld				
33	Runkle 1982	Hueston				
34	Runkle et al. 1984	Hueston				
35	Schmelz 1964	Logansport				
35	Schmelz 1964	Pine Hills				
35	Schmelz 1964	Pioneer Mothers				
35	Schmelz 1964	Rosbrugh				
35	Schmelz 1964	Warren				

(Table 15 continued on next page)

(Table 15 continued)

Map Key	Source/Date	Stand	Fallen Dead Trees (Logs): Density of Logs (#/ha)	Fallen Dead Trees (Logs): Volume of Logs (m^3/ha)	Fallen Dead Trees (Logs): Min Diam Logs (cm)	Total CWD Volume (m^3/ha)
36	Schneider 1963	Toumey	[19]			
37	Spetich et al. 1996	Engelmann Woods		48.5	10	
37	Spetich et al. 1996	Spitler Woods		81.2	10	
38	Stai and Mladenoff 1993	Bowstring Lake		84.8 [20]	15	98.8
38	Stai and Mladenoff 1993	Ludwig Management Area		22.6 [21]	15	37.9
38	Stai and Mladenoff 1993	Moose Mountain Scientific and Natural Area		51.0 [22]	15	112.7
38	Stai and Mladenoff 1993	Mt. Trudee		21.2 [23]	15	48.2
38	Stai and Mladenoff 1993	New Dosey		8.7 [24]	15	10.0
38	Stai and Mladenoff 1993	Nipisiquit Lake		51.1 [25]	15	113.1
38	Stai and Mladenoff 1993	Prairie River		5.0 [26]	15	13.0
38	Stai and Mladenoff 1993	Savanna Prairie		25.0 [27]	15	27.8
38	Stai and Mladenoff 1993	Soo Line Railroad		7.7 [28]	15	8.6
38	Stai and Mladenoff 1993	Spring Beauty Scientific and Natural Area		11.8 [29]	15	33.5
38	Stai and Mladenoff 1993	Tom Lake		11.1 [30]	15	67.4
39	Stearns 1956	Versailles State Park--Potzger				
40	Sudia 1960	Blacklick				
41	Thompson 1991	Plagge Woods	[31]	[32]		
42	Tyrrell 1988d	Hunt Hill				
43	Woods 1979	Warren				

[1] Mortality and ingrowth data presented.
[2] Log volume adjusted for interior decay is 51.4.
[3] Log volume adjusted for interior decay is 96.4.
[4] Log volume adjusted for interior decay is 32.6.
[5] Log volume adjusted for interior decay is 41.5.
[6] Log volume adjusted for interior decay is 12.1.
[7] Log volume adjusted for interior decay is 55.0.
[8] Log volume adjusted for interior decay is 23.4.
[9] Log volume adjusted for interior decay is 59.4.
[10] Log volume adjusted for interior decay is 75.6.
[11] Log volume adjusted for interior decay is 23.6.
[12] Log volume adjusted for interior decay is73.9.
[13] Log volume adjusted for interior decay is 72.0.
[14] Basal area of logs 3.2 m^2/ha.
[15] Basal area of logs 1.0 m^2/ha.
[16] Basal area of logs 4.0 m^2/ha.
[17] Basal area of logs 5.5 m^2/ha.
[18] Basal area of logs 1.3 m^2/ha.
[19] Mortality rates given.
[20] Volume of logs for the dominant species only = 48.7

(Table 15 continued on next page)

(Table 15 continued)

[21] Volume of logs for the dominant species only = 5.3.
[22] Volume of logs for the dominant species only = 31.0.
[23] Volume of logs for the dominant species only = 21.2.
[24] Volume of logs for the dominant species only = 4.0.
[25] Volume of logs for the dominant species only = 6.1.
[26] Volume of logs for the dominant species only = 5.0.
[27] Volume of logs for the dominant species only = 17.0.
[28] Volume of logs for the dominant species only = 5.3.
[29] Volume of logs for the dominant species only = 6.5.
[30] Volume of logs for the dominant species only = 4.7.
[31] Storm in May 1991 blew down 383 trees/ha (not included in log tally).
[32] Basal area of logs = 0.6 m^2/ha, blowdown basal area = 34 m^2/ha.

Table 16.—*Summary of attributes for old-growth beech-maple-basswood stands (from Tables 7 through 15).*

Attribute	Range	References (Map Key)
Live Tree Density (#/ha)		
- Trees ≥ 2 cm d.b.h.	3700 - 4500	37
- Trees ≥ 10 cm d.b.h.	140 - 772	1, 2, 5, 6, 7, 10, 11, 13, 15, 16, 17, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 31, 32, 34, 35, 38, 39, 40, 41, 42
- Trees ≥ 20 cm d.b.h.	70 - 350	2, 14, 15, 16, 27, 28, 32, 34, 42, 43
- Trees ≥ 50 cm d.b.h.	0 - 213	2, 13, 16, 20, 21, 22, 23, 24, 27, 28, 34, 39, 42, 43
- Trees ≥ 70 cm d.b.h.	0 - 107	2, 13, 16, 22, 23, 24, 27, 28, 29, 34, 39, 43
Live Tree Basal Area (m^2/ha)		
- Trees ≥ 2 cm d.b.h.	24.2 - 30.4	37
- Trees ≥ 10 cm d.b.h.	14.4 - 69.1	1, 5, 6, 10, 11, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 28, 29, 31, 32, 34, 35, 38, 39, 40, 41, 42
- Trees ≥ 50 cm d.b.h.	0 - 20.5	39
- Trees ≥ 70 cm d.b.h.	0 - 10.0	39
Tree or Stand Age (yr)		
Average Age by Species		
- Sugar Maple	77 - 302+	4, 11, 36, 39
- American Beech	250 - 290	4, 36
- American Basswood	63 - 187	11, 36, 39
- Elm spp.	235	36
- Red Oak	95 - 124	11
- Other	124 - 172	13
Maximum Tree Diameter at Breast Height by Species (cm)		
- Sugar Maple	35 - 101	2, 4, 6, 8, 10, 16, 19, 21, 22, 23, 24, 25, 26, 28, 29, 32, 34, 36 39, 42
- American Beech	37 - 116	4, 8, 16, 22, 24, 25, 26, 28, 29, 31, 32, 34, 36
- American Basswood	33 - 127	2, 3, 4, 6, 8, 10, 16, 17, 19, 21, 22, 23, 24, 28, 32, 36, 39, 42
- Elm spp.	11 - 128	2, 3, 4, 8, 10, 19, 22, 25, 26, 28, 29, 30, 32, 34, 36
- Red Oak	45 - 127	3, 8, 10, 16, 19, 21, 22, 23, 26, 28, 29, 32, 36, 41, 42
- Yellow-Poplar	29 - 158	3, 16, 26, 28, 29, 30, 32, 34

(Table 16 continued on next page)

(Table 16 continued)

Attribute	Range	References (Map Key)
Average Canopy Height (m)	17 - 37	2, 3, 6, 7, 16, 29
Canopy Gaps (%)	2.6 - 7.0	6, 8, 33, 34
Standing Dead Trees (Snags)		
Snag Density (#/ha)		
- Snags ≥ 2 cm d.b.h.	99 - 131	13, 20, 21, 22, 23, 24, 39, 41, 42
- Snags ≥ 10 cm d.b.h.	0 - 173	37
- Snag Volume (m^3/ha)		
- Snags ≥ 10 cm d.b.h.	0 - 78.7	13
- Snags ≥ 15 cm d.b.h.	0.9 - 44.8	39
Fallen Dead Trees (Logs)		
Density of Logs (#/ha)		
- Logs ≥ 10 cm d.b.h.	100 - 613	13
Volume of Logs (m^3/ha)		
- Logs ≥ 10 cm d.b.h.	12.3 - 121.3	13, 37
- Logs ≥ 15 cm d.b.h.	5.0 - 84.8	39
Total Volume of Coarse Woody Debris (Snags and Logs) (m^3/ha)		
- Snags and Logs ≥ 15 cm	8.6 - 145.8	13, 39

NORTHERN HARDWOOD FORESTS

COMMUNITY COMPOSITION

Forest Cover Types

The following Society of American Foresters (SAF) forest cover types (Eyre 1980) are included in the northern hardwood forest type group:

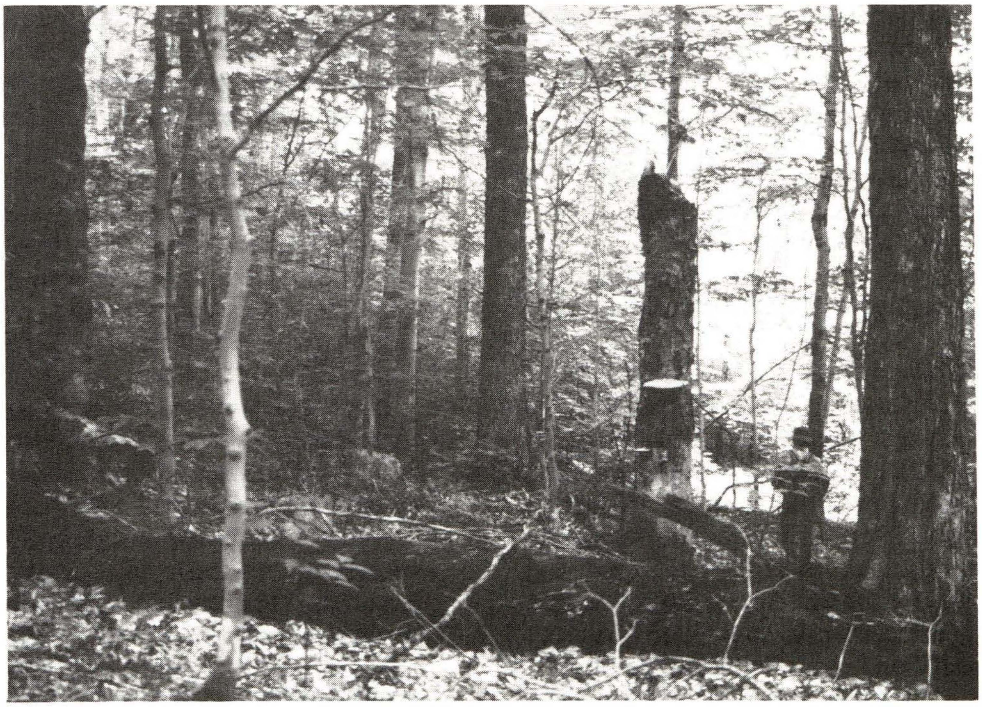
25 - sugar maple-beech-yellow birch
27 - sugar maple
28 - black cherry-maple
60 - beech-sugar maple

The following Combined Data System (CDS) forest cover types for the USDA Forest Service Eastern Region (USDA 1974) are included in the northern hardwood forest type group:

81 - sugar maple/beech/yellow birch
85 - sugar maple
87 - sugar maple/beech/yellow birch/red spruce
89 - mixed hardwoods

Species Composition

Sugar maple (*Acer saccharum* Marsh.), American beech (*Fagus grandifolia* Ehrh.), and yellow birch (*Betula alleghenienisis* Britton) are the dominant northern hardwood species. American beech drops out as a component beyond the western limit of its range in eastern Wisconsin. Deciduous associates include American basswood (*Tilia americana* L.), white ash (*Fraxinus americana* L.), red maple (*Acer rubrum* L.), black cherry (*Prunus serotina* Ehrh.), northern red oak (*Quercus rubra* L.), and yellow-poplar (*Liriodendron tulipifera* L.). Elm (*Ulmus* sp. L.) was formerly common in these forests. Dutch elm disease and elm yellows, however, have sharply diminished the abundance of elm in the overstory. Eastern hemlock (*Tsuga canadensis* (L.) Carr.), eastern white pine (*Pinus strobus* L.), red spruce (*Picea rubens* Sarg.), and balsam fir (*Abies balsamea* (L.) Mill.) are frequent associates; however, their combined overstory coverage along with other conifers is less than 25 percent (*cf*, conifer-northern hardwood forests).



▲ ***The Bowl Research Natural Area*** *includes old-growth northern hardwoods in a relatively undisturbed watershed on the White Mountain National Forest in New Hampshire. See Carbonneau (1986a), Leak (1973, 1974, 1985a, 1985b, 1987a), Leak and Graber (1974), and Martin (1977, 1979). Photo 7/92 by Lucy Tyrrell.*

PHYSICAL CONTEXT

Physiographic Provinces

Northern hardwood forests occur in the following physiographic provinces (after Fenneman 1938):

Blue Ridge	(all sections)
Ridge and Valley	(all sections)
Appalachian Plateaus	(all sections)
New England	(all sections)
Adirondack	
Central Lowland	(Great Lake, Driftless, and Western Young Drift sections)
Superior Upland	

Ecological Units

Northern hardwood forests occur in several divisions and provinces (see Keys *et al.* 1995):

200	Humid Temperate Domain
210	Warm Continental Division
212	Laurentian Mixed Forest Province
220	Hot Continental Division
221	Eastern Broadleaf Forest (Oceanic) Province
M210	Warm Continental Regime Mountains
M212	Adirondack-New England Mixed Forest-Coniferous Forest-Alpine Meadow Province
M220	Hot Continental Regime Mountains
M221	Central Appalachian Broadleaf Forest-Coniferous Forest-Meadow Province

Geographic Distribution

Northern hardwood forests are limited to the northern tier of states in the East, except for a southern extension along the Appalachian Mountains (Bormann and Likens 1979a). The distribution of yellow birch (*Betula alleghaniensis* Britton) essentially demarcates the southern boundary of this forest type group, which stretches from northwest Minnesota to Maine and extends southward from Maine to North Carolina, primarily along the Appalachian Mountains (Burns and Honkala 1990b).

Soils

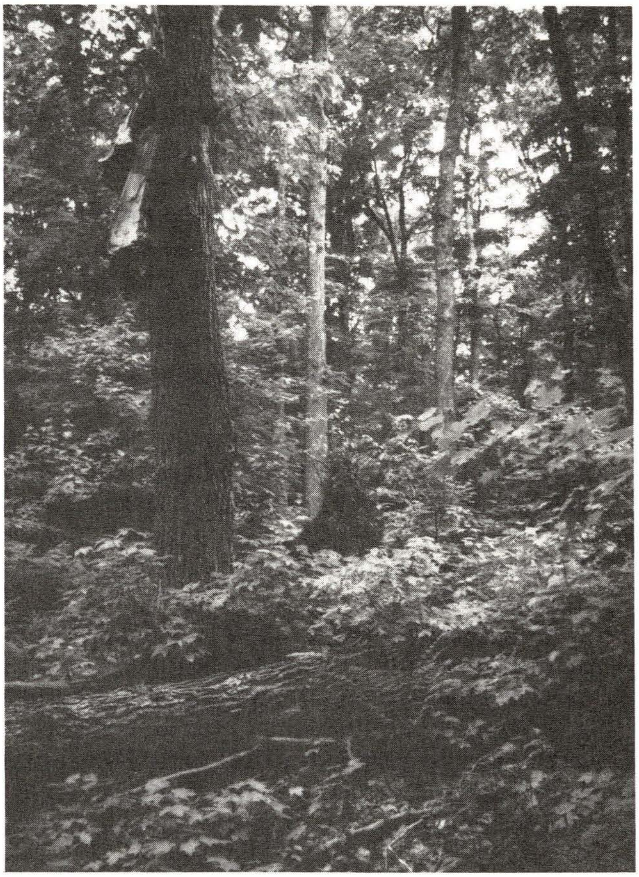
In the North, northern hardwood forests occur on well- to moderately well-drained sites and are best developed on fertile, mesic Alfisols at low to middle elevations. In the middle and southern Appalachians, northern hardwoods are restricted to high elevations with cool, mesic conditions. These conditions are most prevalent on north- and east-facing slopes where direct radiation and evapotranspiration rates are reduced. These forests are poorly developed in certain parts of the middle Appalachians where mountains are relatively low (*e.g.,* Ridge and Valley Province).

DISTURBANCE

Canopy gaps formed by single or multiple tree falls are common (Canham 1985). Under steady-state conditions, microcyclic succession among dominant species may occur (Forcier 1975). Sites supporting northern hardwoods are generally moist, so fires are infrequent and usually limited to small surface burns. Additional disturbances, such as ice and wind storms, occur periodically and range in intensity from catastrophic destruction to less than 10 percent canopy removal (Frelich and Lorimer 1991). The potential for presettlement northern hardwood forests to achieve climax and possibly steady-state conditions may have been greatest in the mountains of the Northeast, where fires and catastrophic wind events appear to be less frequent than in other areas within the range of northern hardwoods (Bormann and Likens 1979b, Lorimer 1977). Disturbance patterns have undoubtedly been altered by human activities such as logging and fire suppression since European settlement (Bormann and Likens 1979b). Though stand stature may be set back, small disturbances rarely alter species composition significantly. More severe disturbances, though rare, may increase the importance of species such as eastern white pine, paper birch (*Betula papyrifera* Marsh.), aspen (*Populus* sp.), and eastern hemlock (Hough and Forbes 1943, Lorimer 1977, Maissurow 1941).

RELATION TO OTHER FOREST TYPES

Northern hardwood stands are often close to and intermingled with conifer-northern hardwood forests. In montane regions, as elevation



▲ *The influence of natural disturbance on patch formation in an old-growth northern hardwood landscape is apparent in this photo taken in the* ***McCormick Wilderness*** *(also a research natural area), Ottawa National Forest, Michigan. A large gap produced by wind uprooted some trees and snapped off others, increasing coarse woody debris. Photo 7/93 by Lucy Tyrrell.*

increases, northern hardwoods grade into conifer-northern hardwoods in which the conifer component is red spruce. Transitions from northern hardwoods to the hemlock-northern hardwoods and eastern white pine-northern hardwoods may also occur along edaphic gradients. Transitions from conifer-northern hardwoods to northern hardwoods occur as scattered, old conifers (*e.g.*, eastern white pine) die off and are gradually replaced by hardwoods (Kittredge 1934, Maine Critical Areas Program 1983b). Severe disturbances can produce a transition from northern hardwoods to conifer-northern hardwoods, provided such disturbances increase conifer abundance.

Where their distributions overlap, (*i.e.*, in the middle and southern Appalachians), northern hardwood forests are distinguished from mixed mesophytic forests by (1) occurring only on high slopes and ridgetops, (2) having lower tree species richness and diversity than mixed mesophytic forests, and (3) including northern species such as yellow birch and red spruce.

STRUCTURAL CHARACTERISTICS OF OLD-GROWTH STANDS

Information about northern hardwood forests in an old-growth condition is included in Figure 5 and Tables 17 through 26.

SELECTED REPRESENTATIVE OLD-GROWTH STANDS

Maine

Beech Hill, Town of Pittston, Kennebec Co.
(Maine Critical Areas Program 1983b, 1985)

Big Reed Pond Preserve*, Piscataquis Co.
(Cogbill 1985, Maine Critical Areas Program 1983b)

Cobbosseecontee*, Town of Monmouth, Kennebec Co.
(Maine Critical Areas Program 1983b, 1985)

Day Mountain, Franklin Co.
(Maine Critical Areas Program 1985)

Hafey Hardwoods, Aroostook Co.
(Maine Critical Areas Program 1983b, 1985)

Haystack Mountain, Oxford Co.
(Maine Critical Areas Program 1983b)

Hedgehog Mountain, Aroostook Co.
(Selva *et al.* 1989)

Little Bigelow
(Hudson *et al.* 1986, Maine State Planning Office 1986)

Lunksoos Mountain, Penobscot Co.
(Maine Critical Areas Program 1983b, 1985)

Mahoosuc Notch, Oxford Co.
(Maine Critical Areas Program 1983b)

Morrison Mountain, Aroostook Co.
(Selva *et al.* 1989)

Mount Philip, Kennebec Co.
(Maine Critical Areas Program 1985)

Musquacook Hardwoods, Aroostook Co.
(Maine Critical Areas Program 1983b, 1985)

Priestly Mountain*, Piscataquis Co.

Pump Handle, Eagle Lake Township, Piscataquis Co.
(Maine Critical Areas Program 1983b, 1985)

Town of Rockport, Knox Co.
(Maine Critical Areas Program 1983b, 1985)

Trout Pond, Town of Mason, Oxford Co.

Yankeetuladi Hardwoods*, Aroostook Co.
(Maine Critical Areas Program 1983b, 1985)

York, York Co.
(Maine Critical Areas Program 1985)

Massachusetts

Bashbish Brook Watershed, Berkshire-Taconic Region
(Leverett 1991)

Cold River Tract, Berkshire-Taconic Region
(Leverett 1991)

Dunbar Brook Watershed, Berkshire-Taconic Region
(Leverett 1991)

Fife Brook Watershed, Berkshire-Taconic Region
(Leverett 1991)

Mount Everett, east side, Berkshire-Taconic Region, Berkshire Co.
(Leverett 1991)

The Hopper, Mount Greylock, Berkshire-Taconic Region, Berkshire Co.
(Leverett 1991)

Todd Mountain*, near Mohawk Trail State Forest
(Leverett 1988)

Michigan

Alberta, Baraga Co.
(Bourdo 1956)

Dukes Experimental Forest, Upper Peninsula
(Mroz *et al.* 1985, Tubbs 1977)

Huron Mountain Club*, T52-53N R28-29W
(Bourdo 1956)

Isle Royale National Park*, Keweenaw Co.

Keweenaw Point, Keweenaw Co.
(Bourdo 1956)

Lake Gogebic State Park, Gogebic Co.
(Davis 1993)

McCormick Tract, Marquette Co.
(Mroz *et al.* 1985, Pregitzer and Barnes 1984)

Misery Bay, Ontonagon Co.
(Bourdo 1956)

North Fox Island*, Leelanau Co.
(Davis 1993)

Northshore Research Natural Area*, Mackinaw State Forest
(Davis 1993)

Porcupine Mountains Wilderness State Park*
(Davis 1993)

South Fox Island, Leelanau Co.
(Hatt *et al.* 1948)

South Manitou Island, Leelanau Co.
(Hatt *et al.* 1948)

Sylvania Wilderness Area*, Ottawa National Forest

Wells State Park, Menominee Co.
(Davis 1993)

Minnesota

Magney Park, Duluth
(Davis 1993)

Moose Mountain State Scientific and Natural Area, St. Louis Co.
(Davis 1993)

Snively Park, Duluth
(Davis 1993)

Star Island in Cass Lake, Beltrami and Cass Co.
(Braun 1950, Kittredge 1934)

New Hampshire

Bartlett Experimental Forest, White Mountain National Forest
(Leak 1973, 1987b)

Charcoal Hearth, Grafton Co.
(Carbonneau 1986a, Tritton 1980)

Eagle Cliff, Grafton Co.
(Carbonneau 1986a)

Jefferson Notch, Coos Co.
(Wood 1975)

Mountain Pond, White Mountain National Forest, Carroll Co.
(Carbonneau 1986a; Leak 1985a, 1985b, 1987b)

Nancy Brook Scenic Area
(Carbonneau 1986a)

Pittsburg Township, White Mountains
(Braun 1950)

The Bowl Research Natural Area*, White Mountain National Forest
(Carbonneau 1986a; Leak 1973, 1974, 1985a, 1985b, 1987b; Leak and Graber 1974; Martin 1977, 1979)

Waterville Township, White Mountains
(Braun 1950)

Williams Tract, Cheshire Co.
(Carbonneau 1986a, 1986b; Leak 1985a, 1987a)

New York

Ampersand Mountain*, Adirondack Park, Franklin Co.
(Leopold *et al.* 1988)

Baldwin Hill, Adirondack Park, Essex Co.
(Leopold *et al.* 1988)

Catskill Mountains, Ulster and Greene Counties
(McIntosh 1972)

Edmund Niles Huyck Preserve
(Runkle 1982)

Five Ponds Wilderness*, Adirondack Park
(Leopold *et al.* 1988)

Gill Brook*, Town of Keene, Essex Co.

Huntington Forest, SUNY Reserve Natural Area
(Bratton 1976)

Kildare, Adirondack Park, St. Lawrence Co.
(Leopold *et al.* 1988)

McKenzie Mountain, Adirondack Park, Essex Co.
(Leopold *et al.* 1988)

North Carolina

Black Mountain Research Natural Area*, Yancey Co.
(Roe 1987)

Cherry Cove, off Blue Ridge Parkway
(Davis 1993)

Great Smoky Mountains National Park*, also TN
(Bratton 1975, Crandall 1958, Runkle 1982, Russell 1953)

Joyce Kilmer Memorial Forest*, Graham Co.
(Runkle 1982)

Walker Cove Research Natural Area*, near Asheville
(Runkle 1982)

Wayah Bald Area, Nantahala National Forest
(Davis 1993)

Pennsylvania

Ayers Hill Quadrangle, Potter Co.
(Goodlett 1954)

Coudersport Quadrangle, Potter Co.
(Goodlett 1954)

Hearts Content, Warren Co.
(Hough and Forbes 1943, Lutz 1930a)

Kennedy Mills, Lawrence Co.
(Davis 1993)

Lost Lakes, Monroe Co.

Miller Woods, 2 mi. N of Slippery Rock, Butler Co.

Oleona Quadrangle, Potter Co.
(Goodlett 1954)

Prince Gallitzin State Park, Cambria Co.

Promised Land State Park, Pike Co.

Raymond B. Winter State Park, Union Co.

Silvermine Run*, 2 mi. E of Rector, Westmoreland Co.

Tidioute Hotel Woods, Tidioute, Warren Co.

Tionesta Scenic and Research Natural Area*, Allegheny National Forest
(Hough and Forbes 1943, Runkle 1982)

Woodbourne Forest and Wildlife Sanctuary*, Susquehanna Co.
(Runkle 1982)

Vermont

Camel's Hump, Green Mountains, Washington Co.
(Vogelmann *et al.* 1985)

Gifford Woods State Natural Area, Rutland Co.

Lookoff Mountain, Green Mountain National Forest

Lords Hill State Natural Area, Washington Co.
(Davis 1993)

The Cape Research Natural Area, Rutland Co.
(Davis 1993)

Wisconsin

Brule Basin, Douglas Co.
(Fassett 1944)

Gogebic Range, Iron Co.
(Mladenoff and Howell 1980)

Menominee Co.
(Milfred *et al.* 1967)

Canada

Duchesnay Experimental Forest, Quebec
(Messier and Bellefleur 1988)

FOR ADDITIONAL INFORMATION

Additional references that pertain to northern hardwood forests but are not cited in tables or text are listed by forest type group in Appendix C.

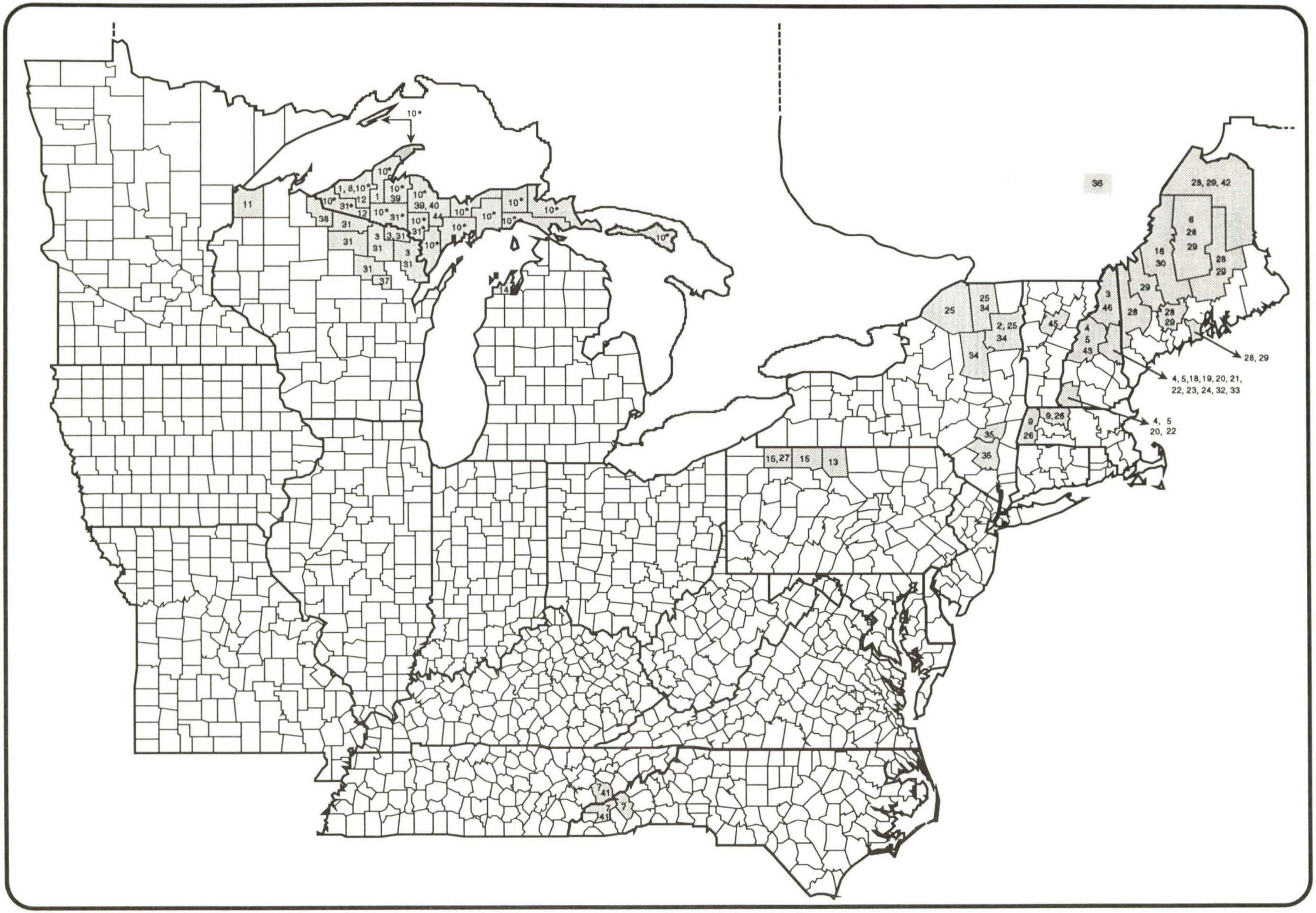

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Figure 5.—*General location of studies that provide stand structure information about old-growth northern hardwood forests. Shaded counties contain at least one study. Numbers correspond to the cited references listed in the Map Key below and in Tables 17 through 26. States are indicated using two-letter postal abbreviations. An asterisk indicates that the county is probable, but not certain. The latitude and longitude of the Canadian study site were estimated from the location information provided by the authors in the cited study. This estimate was used to plot the location of the shaded block on the map.*

Map Key	Source/Date	State or Province	County
1	Bourdo 1956	MI	Houghton, Ontonagon
2	Bratton 1976	NY	Essex
3	Braun 1950	WI	Florence, Forest, Marinette
		NH	Coos
4	Carbonneau 1986a	NH	Carroll, Cheshire, Grafton
5	Carbonneau 1986b	NH	Carroll, Cheshire, Grafton
6	Cogbill 1985	ME	Piscataquis
7	Crandall 1958	NC	Haywood, Swain
		TN	Sevier
8	Dahir and Lorimer 1996	MI	Ontonagon
9	Dunwiddie 1993	MA	Berkshire, Franklin
10	Eyre and Zillgitt 1953	MI	Alger, Baraga, Chippewa, Delta, Dickinson, Gobebic, Houghton, Iron, Keweenaw, Luce, Mackinac, Marquette, Menominee, Ontonagon, Schoolcraft
11	Fassett 1944	WI	Douglas
12	Frelich and Lorimer 1991	MI	Gogebic, Ontonagon
13	Goodlett 1954	PA	Potter
14	Hatt et al. 1948	MI	Leelanau
15	Hough and Forbes 1943	PA	McKean, Warren
16	Hudson et al. 1986	ME	Somerset
17	Kittredge 1934	MN	Beltrami, Cass
18	Leak 1973	NH	Carroll
19	Leak 1974	NH	Carroll
20	Leak 1985a	NH	Carroll, Cheshire
21	Leak 1985b	NH	Carroll
22	Leak 1987a	NH	Carroll, Cheshire
23	Leak 1987b	NH	Carroll
24	Leak and Graber 1974	NH	Carroll
25	Leopold et al. 1988	NY	Essex, Franklin, St. Lawrence
26	Leverett 1991	MA	Berkshire, Franklin
27	Lutz 1930a	PA	Warren
28	Maine Critical Areas Program 1983b	ME	Aroostook, Kennebec, Knox, Oxford, Penobscott, Piscataquis
29	Maine's Critical Areas Program 1985	ME	Aroostook, Franklin, Kennebec, Knox, Penobscott, Piscataquis
30	Maine State Planning Office 1986	ME	Somerset
31	Maissurow 1941	WI	Florence, Forest, Langlade, Marinette, Oneida, Vilas
		MI	Dickinson*, Gogebic*, Iron*
32	Martin 1977	NH	Carroll
33	Martin 1979	NH	Carroll
34	McGee in prep (dissertation)	NY	Essex, Franklin, Hamilton
35	McIntosh 1972	NY	Greene, Ulster
36	Messier and Bellefleur 1988	Quebec	[46°48'N, 71°25'W]
37	Milfred et al. 1967	WI	Menominee
38	Mladenoff and Howell 1980	WI	Iron
39	Mroz et al. 1985	MI	Baraga, Marquette
40	Pregitzer and Barnes 1984	MI	Marquette
41	Russell 1953	NC	Swain
		TN	Sevier
42	Selva et al. 1989	ME	Aroostook
43	Tritton 1980	NH	Grafton
44	Tubbs 1977	MI	Marquette
45	Vogelmann et al. 1985	VT	Washington
46	Wood 1975	NH	Coos

Table 17.—*Location, size, and elevation of northern hardwood old-growth study sites.*

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
1	Bourdo 1956	Misery Bay	MI	Houghton, Ontonagon	unspecified	unspecified
2	Bratton 1976	Huntington Forest--Site 1	NY	Essex	unspecified	500-530
3	Braun 1950	Unspecified	WI	Florence, Forest, Marinette	3.2 [1]	unspecified
3	Braun 1950	Pittsburg Township	NH	Coos	4.9 [2]	unspecified
4	Carbonneau 1986a	Charcoal Hearth	NH	Grafton	30	490-610
4	Carbonneau 1986a	Eagle Cliff	NH	Grafton	25+	585-730
4	Carbonneau 1986a	Mountain Pond	NH	Carroll	60	490-550
4	Carbonneau 1986a	The Bowl	NH	Carroll	206	580-760
4	Carbonneau 1986a	T.V. Williams	NH	Cheshire	20	425-460
5	Carbonneau 1986b	5 stands in New Hampshire	NH	Carroll, Cheshire, Grafton	unspecified	unspecified
5	Carbonneau 1986b	T.V. Williams	NH	Cheshire	unspecified	unspecified
6	Cogbill 1985	Big Reed Pond	ME	Piscataquis	410	unspecified
7	Crandall 1958	Great Smoky Mountains--1524 m	NC, TN	Haywood, Swain (NC); Sevier (TN)	unspecified	1524
7	Crandall 1958	Great Smoky Mountains--1585 m	NC, TN	Haywood, Swain (NC); Sevier (TN)	unspecified	1585
7	Crandall 1958	Great Smoky Mountains--1676 m	NC, TN	Haywood, Swain (NC); Sevier (TN)	unspecified	1676
8	Dahir and Lorimer 1996	Little Carp River--Plot 1	MI	Ontonagon	unspecified	406 [3]
8	Dahir and Lorimer 1996	Little Carp River--Plot 2	MI	Ontonagon	unspecified	382 [3]
8	Dahir and Lorimer 1996	Little Carp River--Plot 3	MI	Ontonagon	unspecified	388 [3]
9	Dunwiddie 1993	Cold River A--Plot 1	MA	Franklin	8	308
9	Dunwiddie 1993	Cold River C--Plot 1	MA	Franklin	17	372
9	Dunwiddie 1993	Cold River E (Manning)--Plot 2	MA	Franklin	5	430
9	Dunwiddie 1993	Dunbar Brook--Plot 1	MA	Berkshire	13	392
9	Dunwiddie 1993	Fife Brook--Plot 1	MA	Berkshire	10	500
9	Dunwiddie 1993	Fife Brook--Plot 2	MA	Berkshire	10	497
9	Dunwiddie 1993	Mt. Greylock (Money Brook)--Plot 2	MA	Berkshire	9	611
10	Eyre and Zillgitt 1953	Upper Peninsula--East	MI	several [4]	unspecified	unspecified
10	Eyre and Zillgitt 1953	Upper Peninsula--West	MI	several [5]	unspecified	unspecified
10	Eyre and Zillgitt 1953	Upper Peninsula	MI	(?) Upper Peninsula	unspecified	unspecified
11	Fassett 1944	Brule River Basin	WI	Douglas	unspecified	unspecified
12	Frelich and Lorimer 1991	28 stands in Upper Peninsula	MI	Gogebic, Ontonagon	unspecified	206-545 [6]
13	Goodlett 1954	Ayers Hill Quadrangle	PA	Potter	unspecified	unspecified
13	Goodlett 1954	Coudersport Quadrangle	PA	Potter	unspecified	unspecified
13	Goodlett 1954	Oleona Quadrangle	PA	Potter	unspecified	unspecified
14	Hatt et al. 1948	South Fox Island	MI	Leelanau	unspecified	102 [7]
14	Hatt et al. 1948	South Manitou Island	MI	Leelanau	unspecified	146 [8]
15	Hough and Forbes 1943	East Tionesta Tract	PA	McKean, Warren	2428	573
15	Hough and Forbes 1943	Hearts Content	PA	Warren	49	unspecified

(Table 17 continued on next page)

(Table 17 continued)

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
16	Hudson et al. 1986	Little Bigelow	ME	Somerset	8+	549-579
17	Kittredge 1934	Star Island--pine to hardwood transition	MN	Beltrami, Cass	486[9]	unspecified
18	Leak 1973	The Bowl	NH	Carroll	18	580-640
18	Leak 1973	Bartlett Experimental Forest--Compartment 26	NH	Carroll	unspecified	335
19	Leak 1974	The Bowl	NH	Carroll	18	580-640
20	Leak 1985a	The Bowl	NH	Carroll	unspecified	610
20	Leak 1985a	Mountain Pond North	NH	Carroll	unspecified	640
20	Leak 1985a	Mountain Pond South	NH	Carroll	unspecified	unspecified
20	Leak 1985a	T.V. Williams	NH	Cheshire	unspecified	457
21	Leak 1985b	The Bowl	NH	Carroll	18	580-640
22	Leak 1987a	The Bowl	NH	Carroll	20	610
22	Leak 1987a	Mountain Pond North	NH	Carroll	41-61	640
22	Leak 1987a	T.V. Williams	NH	Cheshire	8-12[10]	457
23	Leak 1987b	Bartlett--fine till - 450 m	NH	Carroll	}1050[11]	400-475
23	Leak 1987b	Bartlett--fine till - 575 m	NH	Carroll	}	550-600
23	Leak 1987b	Bartlett--coarse washed till - 425 m	NH	Carroll	}	350-500
23	Leak 1987b	Bartlett--coarse washed till - 575 m	NH	Carroll	}	550-600
24	Leak and Graber 1974	The Bowl -- <700 m	NH	Carroll	unspecified	600-699
24	Leak and Graber 1974	The Bowl -- <700 m	NH	Carroll	unspecified	700-799
25	Leopold et al. 1988	Ampersand Mountain 3	NY	Franklin	15	412
25	Leopold et al. 1988	Baldwin Hill	NY	Essex	10	945
25	Leopold et al. 1988	Kildare	NY	St. Lawrence	240	466
25	Leopold et al. 1988	McKenzie Mountain	NY	Essex	60	786
26	Leverett 1991	6 stands in western Massachusetts[12]	MA	Berkshire, Franklin	1214[13]	unspecified
26	Leverett 1991	Cold River	MA	Berkshire, Franklin	unspecified	unspecified
27	Lutz 1930a	Hearts Content	PA	Warren	unspecified	unspecified
28	Maine Critical Areas Program 1983b	Beech Hill	ME	Kennebec	2	450
28	Maine Critical Areas Program 1983b	Big Reed Hardwoods	ME	Piscataquis	4	323-366
28	Maine Critical Areas Program 1983b	Cobbosseecontee	ME	Kennebec	4.5	200
28	Maine Critical Areas Program 1983b	Hafey Hardwoods	ME	Aroostook	41	396
28	Maine Critical Areas Program 1983b	Haystack Mountain	ME	Oxford	2.8	549
28	Maine Critical Areas Program 1983b	Lunksoos Mountain Hardwoods	ME	Penobscott	4	347
28	Maine Critical Areas Program 1983b	Mahoosuc Notch	ME	Oxford	2	671
28	Maine Critical Areas Program 1983b	Musquacook Hardwoods	ME	Aroostook	51	457
28	Maine Critical Areas Program 1983b	Pump Handle	ME	Piscataquis	1.2	335
28	Maine Critical Areas Program 1983b	Rockport	ME	Knox	4	140-160
28	Maine Critical Areas Program 1983b	Yankeetuladi Hardwoods	ME	Aroostook	97	366

(Table 17 continued on next page)

(Table 17 continued)

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
29	Maine's Critical Areas Program 1985	Beech Hill	ME	Kennebec	2	unspecified
29	Maine's Critical Areas Program 1985	Cobbosseecontee	ME	Kennebec	4.5	unspecified
29	Maine's Critical Areas Program 1985	Day Mountain	ME	Franklin	8	unspecified
29	Maine's Critical Areas Program 1985	Hafey	ME	Aroostook	41	unspecified
29	Maine's Critical Areas Program 1985	Lunksoos	ME	Penobscot	4	unspecified
29	Maine's Critical Areas Program 1985	Mount Philip	ME	Kennebec	0.4	unspecified
29	Maine's Critical Areas Program 1985	Musquacook	ME	Aroostook	51	unspecified
29	Maine's Critical Areas Program 1985	Pump Handle	ME	Piscataquis	1.2	unspecified
29	Maine's Critical Areas Program 1985	Rockport	ME	Knox	4	unspecified
29	Maine's Critical Areas Program 1985	Yankeetuladi	ME	Aroostook	97	unspecified
30	Maine State Planning Office 1986	Little Bigelow	ME	Somerset	8+	549-579
31	Maissurow 1941	22 stands in Wisconsin, Michigan [14]	MI, WI	several [15]	unspecified	unspecified
32	Martin 1977	The Bowl--entire watershed	NH	Carroll	607 [16]	575-915
32	Martin 1977	The Bowl--Area I (West Branch Watershed)	NH	Carroll	206	unspecified
32	Martin 1977	The Bowl--Area II (West Branch Watershed)	NH	Carroll	unspecified	unspecified
32	Martin 1977	The Bowl--Area III (East Branch Watershed)	NH	Carroll	unspecified	unspecified
32	Martin 1977	The Bowl--Area IV (East Branch Watershed)	NH	Carroll	unspecified	unspecified
33	Martin 1979	The Bowl	NH	Carroll	607 [17]	unspecified
34	McGee in prep (dissertation)	Ampersand Mountain	NY	Franklin	unspecified	480
34	McGee in prep (dissertation)	Catlin Lake (Huntington Forest)	NY	Hamilton	unspecified	550-560
34	McGee in prep (dissertation)	Gill Brook (Ausable Club)	NY	Essex	unspecified	640-650
34	McGee in prep (dissertation)	Mason Lake	NY	Hamilton	unspecified	540-570
34	McGee in prep (dissertation)	Moose Mountain	NY	Hamilton	unspecified	470-490
34	McGee in prep (dissertation)	Sucker Brook	NY	Hamilton	unspecified	640-660
34	McGee in prep (dissertation)	Whalestail Mountain	NY	Essex	unspecified	680-690
35	McIntosh 1972	Catskill Mountains--9 stands listed below	NY	Greene, Ulster	unspecified	unspecified
35	McIntosh 1972	Catskill Mountains--Stand 37	NY	Greene, Ulster	unspecified	640
35	McIntosh 1972	Catskill Mountains--Stand 38	NY	Greene, Ulster	unspecified	823
35	McIntosh 1972	Catskill Mountains--Stand 48	NY	Greene, Ulster	unspecified	792
35	McIntosh 1972	Catskill Mountains--Stand 61	NY	Greene, Ulster	unspecified	853
35	McIntosh 1972	Catskill Mountains--Stand 63	NY	Greene, Ulster	unspecified	762
35	McIntosh 1972	Catskill Mountains--Stand 78	NY	Greene, Ulster	unspecified	1036
35	McIntosh 1972	Catskill Mountains--Stand 81	NY	Greene, Ulster	unspecified	671
35	McIntosh 1972	Catskill Mountains--Stand 104	NY	Greene, Ulster	unspecified	823
35	McIntosh 1972	Catskill Mountains--Stand 106	NY	Greene, Ulster	unspecified	701
36	Messier and Bellefleur 1988	Duchesnay Experimental Forest	Quebec	[46°48'N, 71°25'W]	unspecified	unspecified
37	Milfred et al. 1967	Menominee County--Stand #7	WI	Menominee	unspecified	190-434 [18]

(Table 17 continued on next page)

(Table 17 continued)

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
37	Milfred et al. 1967	Menominee County--Stand #19	WI	Menominee	unspecified	190-434 [18]
38	Mladenoff and Howell 1980	Gogebic Iron Range--sugar maple-dominated	WI	Iron	8398 [19]	335-580 [20]
38	Mladenoff and Howell 1980	Gogebic Iron Range--yellow birch-dominated	WI	Iron	1742 [21]	335-580 [20]
39	Mroz et al. 1985	McCormick Experimental Forest Natural Area	MI	Baraga, Marquette	1488	460-580
39	Mroz et al. 1985	Upper Peninsula/Dukes	MI	Marquette	94	275-335
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 2	MI	Marquette	198 [22]	unspecified
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 4	MI	Marquette	369 [22]	unspecified
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 5	MI	Marquette	35 [22]	unspecified
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 7	MI	Marquette	99 [22]	unspecified
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 11	MI	Marquette	41 [22]	unspecified
41	Russell 1953	Double Springs	TN	Sevier	unspecified	1524+
41	Russell 1953	Unspecified (4 beech gaps)	NC, TN	Swain (NC), Sevier (TN)	unspecified	1524+
42	Selva et al. 1989	Hedgehog Mountain	ME	Aroostook	unspecified	unspecified
42	Selva et al. 1989	Morrison Mountain	ME	Aroostook	unspecified	unspecified
43	Tritton 1980	Charcoal Hearth	NH	Grafton	6	457
44	Tubbs 1977	Upper Peninsula/Dukes--tract before cutting in 1938	MI	Marquette	16	unspecified
44	Tubbs 1977	Upper Peninsula/Dukes--virgin tract	MI	Marquette	unspecified	unspecified
45	Vogelmann et al. 1985	Camel's Hump--1965	VT	Washington	unspecified	550-730
45	Vogelmann et al. 1985	Camel's Hump--1979	VT	Washington	unspecified	550-730
45	Vogelmann et al. 1985	Camel's Hump--1983	VT	Washington	unspecified	550-730
46	Wood 1975	Jefferson Notch	NH	Coos	unspecified	unspecified

[1] Total area sampled in 3 counties.

[2] Total area sampled.

[3] Elevation information from Frelich (1986).

[4] Alger, Chippewa, Delta, Luce, Mackinac, Menominee, Schoolcraft.

[5] Baraga, Dickinson, Gogebic, Houghton, Iron, Keweenaw, Marquette, Ontonagon.

[6] Range of elevations for plots as given in Frelich (1986).

[7] Maximum elevation of South Fox Island.

[8] Maximum elevation of South Manitou Island.

[9] Area of entire island.

[10] Area studied within larger tract.

[11] Area of entire Bartlett Experiment Forest.

[12] The Hopper (Mt. Greylock)/Cold River/Fife Brook/Dunbar Brook/Bashbish Brook/Mt. Everett.

[13] Area of all stands.

[14] 22 virgin stands within the Nicolet National Forest and 16 km north of Wisconsin-Michigan border.

[15] Florence, Forest, Langlade, Marinette, Oneida, Vilas (WI); likely to be Dickinson, Iron, and Gogebic in MI.

[16] Values are from the entire 607-ha watershed, which contains conifer-hardwood stands at elevations of 750-915 m.

[17] Values are from the entire 607-ha watershed.

[18] Elevation range for entire county.

[19] Area occupied by sugar maple-dominated communities in 1860s.

[20] Range of elevations for entire study area.

[21] Area occupied by yellow birch-dominated communities in 1860s.

[22] Area covered by the site unit within the 1500-ha Natural Area.

Table 18.—*Criteria, used by sources to identify old-growth stands, and information about stand composition of the northern hardwood old-growth study sites.*

Map Key	Source/Date	Stand	Criteria for Stand Selection and Stand Composition
1	Bourdo 1956	Misery Bay	Uncut timber
2	Bratton 1976	Huntington Forest--Site 1	Mature; little indication of disturbance
3	Braun 1950	Unspecified	Virgin forest
3	Braun 1950	Pittsburg Township	Original forest types
4	Carbonneau 1986a	Charcoal Hearth	Criteria for old growth
4	Carbonneau 1986a	Eagle Cliff	Criteria for old growth
4	Carbonneau 1986a	Mountain Pond	Criteria for old growth
4	Carbonneau 1986a	The Bowl	Criteria for old growth
4	Carbonneau 1986a	T.V. Williams	Criteria for old growth
5	Carbonneau 1986b	5 stands in New Hampshire	Criteria for old growth
5	Carbonneau 1986b	T.V. Williams	Criteria for old growth
6	Cogbill 1985	Big Reed Pond	Old growth, no known harvesting or disturbance
7	Crandall 1958	Great Smoky Mountains--1524 m	Trees with large diameters
7	Crandall 1958	Great Smoky Mountains--1585 m	Trees with large diameters
7	Crandall 1958	Great Smoky Mountains--1676 m	Trees with large diameters
8	Dahir and Lorimer 1996	Little Carp River--Plot 1	Crown area % (see Frelich and Lorimer 1991); sugar maple (56%)-hemlock (24%)
8	Dahir and Lorimer 1996	Little Carp River--Plot 2	Crown area % (see Frelich and Lorimer 1991); sugar maple (60%)-hemlock (23%)
8	Dahir and Lorimer 1996	Little Carp River--Plot 3	Crown area % (see Frelich and Lorimer 1991); sugar maple (74%)-hemlock (34%)
9	Dunwiddie 1993	Cold River A--Plot 1	Several criteria (size, age, minimal disturbance); sugar maple (45%)-beech (28%) [1]
9	Dunwiddie 1993	Cold River C--Plot 1	Several criteria (size, age, minimal disturbance); sugar maple (62%)-white ash (18%) [1]
9	Dunwiddie 1993	Cold River E (Manning)--Plot 2	Several criteria (size, age, minimal disturbance); sugar maple (72%)-hemlock (10%) [1]
9	Dunwiddie 1993	Dunbar Brook--Plot 1	Several criteria (size, age, minimal disturbance); sugar maple (66%)-white ash (5%) [1]
9	Dunwiddie 1993	Fife Brook--Plot 1	Several criteria (size, age, minimal disturbance); sugar maple (55%)-beech (45%) [1]
9	Dunwiddie 1993	Fife Brook--Plot 2	Several criteria (size, age, minimal disturbance); sugar maple (74%)-beech (23%) [1]
9	Dunwiddie 1993	Mt. Greylock (Money Brook)--Plot 2	Several criteria (size, age, minimal disturbance); sugar maple (60%)-white ash (19%) [1]
10	Eyre and Zillgitt 1953	Upper Peninsula--East	Old-growth northern hardwoods
10	Eyre and Zillgitt 1953	Upper Peninsula--West	Old-growth northern hardwoods
10	Eyre and Zillgitt 1953	Upper Peninsula	Old-growth northern hardwoods
11	Fassett 1944	Brule River Basin	Survey records of original vegetation [2]
12	Frelich and Lorimer 1991	28 stands in Upper Peninsula	Crown area comprised >=67% of trees >=26 cm d.b.h.; primary forest
13	Goodlett 1954	Ayers Hill Quadrangle	Stands containing a few large, old hardwood trees
13	Goodlett 1954	Coudersport Quadrangle	Stands containing a few large, old hardwood trees
13	Goodlett 1954	Oleona Quadrangle	Stands containing a few large, old hardwood trees
14	Hatt et al. 1948	South Fox Island	Virgin (some areas)
14	Hatt et al. 1948	South Manitou Island	Virgin (some areas)
15	Hough and Forbes 1943	East Tionesta Tract	Old-growth remnants (in part)
15	Hough and Forbes 1943	Hearts Content	Virgin timber

(Table 18 continued on next page)

(Table 18 continued)

Map Key	Source/Date	Stand	Criteria for Stand Selection and Stand Composition
16	Hudson et al. 1986	Little Bigelow	Old growth
17	Kittredge 1934	Star Island--pine to hardwood transition [3]	Evidence of several fires; less disturbed than mainland; northern hardwoods-pine [3]
18	Leak 1973	The Bowl	Virgin forest
18	Leak 1973	Bartlett Experimental Forest--Compartment 26	Old growth; high-graded in late 1800's but uncut since
19	Leak 1974	The Bowl	Virgin forest, never logged
20	Leak 1985a	The Bowl	Virgin
20	Leak 1985a	Mountain Pond North	Virgin
20	Leak 1985a	Mountain Pond South	Overmature
20	Leak 1985a	T.V. Williams	Overmature
21	Leak 1985b	The Bowl	Old growth, virgin
22	Leak 1987a	The Bowl	Steady-state condition
22	Leak 1987a	Mountain Pond North	Steady-state condition
22	Leak 1987a	T.V. Williams	Steady-state condition
23	Leak 1987b	Bartlett--fine till - 450 m	Uncut; undamaged by 1938 hurricane; lightly high-graded before 1890-1900
23	Leak 1987b	Bartlett--fine till - 575 m	Uncut; undamaged by 1938 hurricane; lightly high-graded before 1890-1900
23	Leak 1987b	Bartlett--coarse washed till - 425 m	Uncut; undamaged by 1938 hurricane; lightly high-graded before 1890-1900
23	Leak 1987b	Bartlett--coarse washed till - 575 m	Uncut; undamaged by 1938 hurricane; lightly high-graded before 1890-1900
24	Leak and Graber 1974	The Bowl	Never logged
24	Leak and Graber 1974	The Bowl	Never logged
25	Leopold et al. 1988	Ampersand Mountain 3	Old growth
25	Leopold et al. 1988	Baldwin Hill	Old growth
25	Leopold et al. 1988	Kildare	Old growth
25	Leopold et al. 1988	McKenzie Mountain	Old growth
26	Leverett 1991	6 stands in western Massachusetts	Old growth or near old growth
26	Leverett 1991	Cold River	Old growth or near old growth
27	Lutz 1930a	Hearts Content	Virgin forest; limited cutting; data from ungrazed areas
28	Maine Critical Areas Program 1983b	Beech Hill	Uncut
28	Maine Critical Areas Program 1983b	Big Reed Hardwoods	Old growth; uncut, undisturbed
28	Maine Critical Areas Program 1983b	Cobbosseecontee	Old growth; no evidence of past fire
28	Maine Critical Areas Program 1983b	Hafey Hardwoods	Old growth, no signs of any cutting, trees 275+ years old
28	Maine Critical Areas Program 1983b	Haystack Mountain	Uncut
28	Maine Critical Areas Program 1983b	Lunksoos Mountain Hardwoods	Moderately old; entirely natural; uncut
28	Maine Critical Areas Program 1983b	Mahoosuc Notch	Undisturbed, old condition
28	Maine Critical Areas Program 1983b	Musquacook Hardwoods	Old growth; entirely natural; uncut
28	Maine Critical Areas Program 1983b	Pump Handle	Old-growth specimens, no signs of past cutting; sugar maple-beech
28	Maine Critical Areas Program 1983b	Rockport	No evidence of cutting
28	Maine Critical Areas Program 1983b	Yankeetuladi Hardwoods	Uncut, entirely natural old growth with trees >230 years old

(Table 18 continued on next page)

(Table 18 continued)

Map Key	Source/Date	Stand	Criteria for Stand Selection and Stand Composition
29	Maine's Critical Areas Program 1985	Beech Hill	Old growth
29	Maine's Critical Areas Program 1985	Cobbosseecontee	Old growth
29	Maine's Critical Areas Program 1985	Day Mountain	Old growth
29	Maine's Critical Areas Program 1985	Hafey	Old growth
29	Maine's Critical Areas Program 1985	Lunksoos	Old growth
29	Maine's Critical Areas Program 1985	Mount Philip	Old growth
29	Maine's Critical Areas Program 1985	Musquacook	Old growth
29	Maine's Critical Areas Program 1985	Pump Handle	Old growth
29	Maine's Critical Areas Program 1985	Rockport	Old growth
29	Maine's Critical Areas Program 1985	Yankeetuladi	Old growth
30	Maine State Planning Office 1986	Little Bigelow	Old growth
31	Maissurow 1941	22 stands in Wisconsin, Michigan	Remnants of virgin forest
32	Martin 1977	The Bowl--entire watershed	Virgin forest; some areas disturbed in the past
32	Martin 1977	The Bowl--Area I (West Branch Watershed)	No evidence of past logging
32	Martin 1977	The Bowl--Area II (West Branch Watershed)	No data on past disturbance available
32	Martin 1977	The Bowl--Area III (East Branch Watershed)	Some areas logged ca. 1888; disturbance of 24 ha by 1938 hurricane possible
32	Martin 1977	The Bowl--Area IV (East Branch Watershed)	Some areas logged ca. 1888
33	Martin 1979	The Bowl	Part of watershed with no history of logging, human settlement, or fire
34	McGee in prep (dissertation)	Ampersand Mountain	Contain individuals with ages >=maximum expected age for species
34	McGee in prep (dissertation)	Catlin Lake (Huntington Forest)	Contain individuals with ages >=maximum expected age for species
34	McGee in prep (dissertation)	Gill Brook (Ausable Club)	Contain individuals with ages >=maximum expected age for species
34	McGee in prep (dissertation)	Mason Lake	Contain individuals with ages >=maximum expected age for species
34	McGee in prep (dissertation)	Moose Mountain	Contain individuals with ages >=maximum expected age for species
34	McGee in prep (dissertation)	Sucker Brook	Contain individuals with ages >=maximum expected age for species
34	McGee in prep (dissertation)	Whalestail Mountain	Contain individuals with ages >=maximum expected age for species
35	McIntosh 1972	Catskill Mountains--9 stands listed below	Old growth; trees 200+ years old
35	McIntosh 1972	Catskill Mountains--Stand 37	Old growth; trees 200+ years old; hemlock [4]
35	McIntosh 1972	Catskill Mountains--Stand 38	Old growth; trees 200+ years old; sugar maple
35	McIntosh 1972	Catskill Mountains--Stand 48	Old growth; trees 200+ years old; sugar maple
35	McIntosh 1972	Catskill Mountains--Stand 61	Old growth; trees 200+ years old; hemlock [4]
35	McIntosh 1972	Catskill Mountains--Stand 63	Old growth; trees 200+ years old; beech [4]
35	McIntosh 1972	Catskill Mountains--Stand 78	Old growth; trees 200+ years old; sugar maple
35	McIntosh 1972	Catskill Mountains--Stand 81	Old growth; trees 200+ years old; hemlock [4]
35	McIntosh 1972	Catskill Mountains--Stand 104	Old growth; trees 200+ years old; beech [4]
35	McIntosh 1972	Catskill Mountains--Stand 106	Old growth; trees 200+ years old; beech [4]
36	Messier and Bellefleur 1988	Duchesnay Experimental Forest	Undisturbed old growth
37	Milfred et al. 1967	Menominee County--Stand #7	Terminal forest; all-age structure; may have had some disturbance

(Table 18 continued on next page)

(Table 18 continued)

Map Key	Source/Date	Stand	Criteria for Stand Selection and Stand Composition
37	Milfred et al. 1967	Menominee County--Stand #19	Originated after fire in 1830
38	Mladenoff and Howell 1980	Gogebic Iron Range--sugar maple-dominated	Presettlement and pre-mining condition (1856-67 survey)
38	Mladenoff and Howell 1980	Gogebic Iron Range--yellow birch-dominated	Presettlement and pre-mining condition (1856-67 survey)
39	Mroz et al. 1985	McCormick Experimental Forest Natural Area	Old growth with removal of scattered, large white pine about 1900
39	Mroz et al. 1985	Upper Peninsula/Dukes	Old growth; selective removal of elm and basswood in early 1900s
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 2	Old-growth forest; undisturbed; occasional removal of white pine <1930
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 4	Old-growth forest; undisturbed; occasional removal of white pine <1930
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 5	Old-growth forest; undisturbed; occasional removal of white pine <1930
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 7	Old-growth forest; undisturbed; occasional removal of white pine <1930
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 11	Old-growth forest; undisturbed; occasional removal of white pine <1930
41	Russell 1953	Double Springs	Virgin; climax forest for the site
41	Russell 1953	Unspecified (4 beech gaps)	Virgin; climax forest for the site
42	Selva et al. 1989	Hedgehog Mountain	Suspected old-growth forest
42	Selva et al. 1989	Morrison Mountain	Suspected old-growth forest
43	Tritton 1980	Charcoal Hearth	Trees 200+ yr, all aged; no stumps or logging roads, no 1938 hurricane damage
44	Tubbs 1977	Upper Peninsula/Dukes--tract before cutting in 1938	Overmature trees (prior to cutting in 1938)
44	Tubbs 1977	Upper Peninsula/Dukes--virgin tract	Virgin
45	Vogelmann et al. 1985	Camel's Hump--1965	Old-age hardwood forest; no cutting on plots
45	Vogelmann et al. 1985	Camel's Hump--1979	Old-age hardwood forest; no cutting on plots
45	Vogelmann et al. 1985	Camel's Hump--1983	Old-age hardwood forest; no cutting on plots
46	Wood 1975	Jefferson Notch	Mature stand with large trees

[1] Composition percentage based on basal area.

[2] Survey notes indicate that not all original vegetation before logging was old growth.

[3] This forest type contained a few very old white and red pines that were apparently being replaced by younger northern hardwoods.

[4] The hemlock and beech stand types considered collectively contain 41% American beech, 21% sugar maple, 21% eastern hemlock, and 11% yellow birch.

Table 19.—*Methods used to study old-growth northern hardwoods (condensed from the cited references).*

Map Key	Source/Date	Stand	Sampling Methods
1	Bourdo 1956	Misery Bay	Land survey records
2	Bratton 1976	Huntington Forest--Site 1	32 m x 32 m plot
3	Braun 1950	Unspecified	Tally of a total of 3.2 ha in 3 counties
3	Braun 1950	Pittsburg Township	Tally of a total of 4.9 ha
4	Carbonneau 1986a	Charcoal Hearth	2-7 20 m x 20 m plots
4	Carbonneau 1986a	Eagle Cliff	2-7 20 m x 20 m plots
4	Carbonneau 1986a	Mountain Pond	2-7 20 m x 20 m plots
4	Carbonneau 1986a	The Bowl	2-7 20 m x 20 m plots
4	Carbonneau 1986a	T.V. Williams	2-7 20 m x 20 m plots
5	Carbonneau 1986b	5 stands in New Hampshire	Unspecified
5	Carbonneau 1986b	T.V. Williams	Unspecified
6	Cogbill 1985	Big Reed Pond	1833, 1840 survey records; historical records; timber cruise
7	Crandall 1958	Great Smoky Mountains--1524 m	} 59 10 m x 50 m strips, 20 5 m x 50 m strips [1]
7	Crandall 1958	Great Smoky Mountains--1585 m	}
7	Crandall 1958	Great Smoky Mountains--1676 m	}
8	Dahir and Lorimer 1996	Little Carp River--Plot 1	70.7 m x 70.7 m plot randomly located
8	Dahir and Lorimer 1996	Little Carp River--Plot 2	70.7 m x 70.7 m plot randomly located
8	Dahir and Lorimer 1996	Little Carp River--Plot 3	70.7 m x 70.7 m plot randomly located
9	Dunwiddie 1993	Cold River A--Plot 1	1 0.1-ha circular plot
9	Dunwiddie 1993	Cold River C--Plot 1	1 0.1-ha circular plot
9	Dunwiddie 1993	Cold River E (Manning)--Plot 2	1 0.1-ha circular plot
9	Dunwiddie 1993	Dunbar Brook--Plot 1	1 0.1-ha circular plot
9	Dunwiddie 1993	Fife Brook--Plot 1	1 0.1-ha circular plot
9	Dunwiddie 1993	Fife Brook--Plot 2	1 0.1-ha circular plot
9	Dunwiddie 1993	Mt. Greylock (Money Brook)--Plot 2	1 0.1-ha circular plot
10	Eyre and Zillgitt 1953	Upper Peninsula--East	1936 Forest Survey
10	Eyre and Zillgitt 1953	Upper Peninsula--West	1936 Forest Survey
10	Eyre and Zillgitt 1953	Upper Peninsula	Unspecified
11	Fassett 1944	Brule River Basin	Survey records (1852-56); economic maps, soil maps, field checking (1942-43)
12	Frelich and Lorimer 1991	28 stands in Upper Peninsula	1 0.5-ha plot per stand; randomly located; ages based on subsample of 8 stands
13	Goodlett 1954	Ayers Hill Quadrangle	Historical records, general survey, examination of stumps, pits, and mounds
13	Goodlett 1954	Coudersport Quadrangle	Historical records, general survey, examination of stumps, pits, and mounds
13	Goodlett 1954	Oleona Quadrangle	Historical records, general survey, examination of stumps, pits, and mounds
14	Hatt et al. 1948	South Fox Island	General survey, methods unspecified
14	Hatt et al. 1948	South Manitou Island	General survey, methods unspecified
15	Hough and Forbes 1943	East Tionesta Tract	Diameter tallies; study of stumps; ages from tree sections in 10 0.4-ha plots
15	Hough and Forbes 1943	Hearts Content	Unspecified

(Table 19 continued on next page)

(Table 19 continued)

Map Key	Source/Date	Stand	Sampling Methods
16	Hudson et al. 1986	Little Bigelow	Unspecified
17	Kittredge 1934	Star Island--pine to hardwood transition	6 0.1-ha or 0.08-ha plots
18	Leak 1973	The Bowl	0.1-ha plots at 15 locations
18	Leak 1973	Bartlett Experimental Forest--Compartment 26	2 plots
19	Leak 1974	The Bowl	1 0.1-ha plot at ll locations
20	Leak 1985a	The Bowl	26 prism plots
20	Leak 1985a	Mountain Pond North	15 prism plots
20	Leak 1985a	Mountain Pond South	10 prism plots
20	Leak 1985a	T.V. Williams	20 prism plots
21	Leak 1985b	The Bowl	Diameter and age of 338 trees
22	Leak 1987a	The Bowl	Prism plots
22	Leak 1987a	Mountain Pond North	Prism plots
22	Leak 1987a	T.V. Williams	Prism plots
23	Leak 1987b	Bartlett--fine till - 450 m	3 1012-m^2 plots
23	Leak 1987b	Bartlett--fine till - 575 m	6 1012-m^2 plots
23	Leak 1987b	Bartlett--coarse washed till - 425 m	3 1012-m^2 plots
23	Leak 1987b	Bartlett--coarse washed till - 575 m	3 1012-m^2 plots
24	Leak and Graber 1974	The Bowl	Prism plots for each 15.2 m rise in elevation along transect; tree ages
24	Leak and Graber 1974	The Bowl	Prism plots for each 15.2 m rise in elevation along transect; tree ages
25	Leopold et al. 1988	Ampersand Mountain 3	1 20 m x 50 m plot
25	Leopold et al. 1988	Baldwin Hill	1 20 m x 50 m plot
25	Leopold et al. 1988	Kildare	1 20 m x 50 m plot
25	Leopold et al. 1988	McKenzie Mountain	1 20 m x 50 m plot
26	Leverett 1991	6 stands in western Massachusetts	Age estimates; coring dead trees; identifying old-growth trees using bark, form
26	Leverett 1991	Cold River	Age estimates; coring dead trees; identifying old-growth trees using bark, form
27	Lutz 1930a	Hearts Content	60 ungrazed .0004-ha plots
28	Maine Critical Areas Program 1983b	Beech Hill	Diameter and coring of representative trees
28	Maine Critical Areas Program 1983b	Big Reed Hardwoods	Unspecified
28	Maine Critical Areas Program 1983b	Cobbosseecontee	Diameter and age (methods unspecified)
28	Maine Critical Areas Program 1983b	Hafey Hardwoods	Unspecified
28	Maine Critical Areas Program 1983b	Haystack Mountain	3 prism plots
28	Maine Critical Areas Program 1983b	Lunksoos Mountain Hardwoods	1 600-m^2 plot; coring for age determination
28	Maine Critical Areas Program 1983b	Mahoosuc Notch	Unspecified
28	Maine Critical Areas Program 1983b	Musquacook Hardwoods	1 15 m x 50 m quadrat; coring for age determination
28	Maine Critical Areas Program 1983b	Pump Handle	Unspecified
28	Maine Critical Areas Program 1983b	Rockport	Diameter; coring for age determination
28	Maine Critical Areas Program 1983b	Yankeetuladi Hardwoods	1 324-m^2 plot; tree ages

(Table 19 continued on next page)

(Table 19 continued)

Map Key	Source/Date	Stand	Sampling Methods
29	Maine's Critical Areas Program 1985	Beech Hill	Detailed methods not specified
29	Maine's Critical Areas Program 1985	Cobbosseecontee	Detailed methods not specified
29	Maine's Critical Areas Program 1985	Day Mountain	Detailed methods not specified
29	Maine's Critical Areas Program 1985	Hafey	Detailed methods not specified
29	Maine's Critical Areas Program 1985	Lunksoos	Detailed methods not specified
29	Maine's Critical Areas Program 1985	Mount Philip	Detailed methods not specified
29	Maine's Critical Areas Program 1985	Musquacook	Detailed methods not specified
29	Maine's Critical Areas Program 1985	Pump Handle	Detailed methods not specified
29	Maine's Critical Areas Program 1985	Rockport	Detailed methods not specified
29	Maine's Critical Areas Program 1985	Yankeetuladi	Detailed methods not specified
30	Maine State Planning Office 1986	Little Bigelow	Inventory techniques; increment cores; past cutting records
31	Maissurow 1941	22 stands in Wisconsin, Michigan	27 0.1-ha plots; transects totalling 4.0 km; cores from large trees
32	Martin 1977	The Bowl--entire watershed	218 100-m^2 plots
32	Martin 1977	The Bowl--Area I (West Branch Watershed)	28 100-m^2 plots
32	Martin 1977	The Bowl--Area II (West Branch Watershed)	56 100-m^2 plots
32	Martin 1977	The Bowl--Area III (East Branch Watershed)	83 100-m^2 plots
32	Martin 1977	The Bowl--Area IV (East Branch Watershed)	51 100-m^2 plots
33	Martin 1979	The Bowl	Unspecified (Martin 1977 is cited)
34	McGee in prep (dissertation)	Ampersand Mountain	2 randomly located 0.1 ha plots
34	McGee in prep (dissertation)	Catlin Lake (Huntington Forest)	2 randomly located 0.1 ha plots
34	McGee in prep (dissertation)	Gill Brook (Ausable Club)	2 randomly located 0.1 ha plots
34	McGee in prep (dissertation)	Mason Lake	2 randomly located 0.1 ha plots
34	McGee in prep (dissertation)	Moose Mountain	2 randomly located 0.1 ha plots
34	McGee in prep (dissertation)	Sucker Brook	2 randomly located 0.1 ha plots
34	McGee in prep (dissertation)	Whalestail Mountain	2 randomly located 0.1 ha plots
35	McIntosh 1972	Catskill Mountains--9 stands listed below	Counts of annual rings on stumps
35	McIntosh 1972	Catskill Mountains--Stand 37	Point-quarter method, 20 points per stand
35	McIntosh 1972	Catskill Mountains--Stand 38	Point-quarter method, 20 points per stand
35	McIntosh 1972	Catskill Mountains--Stand 48	Point-quarter method, 20 points per stand
35	McIntosh 1972	Catskill Mountains--Stand 61	Point-quarter method, 20 points per stand
35	McIntosh 1972	Catskill Mountains--Stand 63	Point-quarter method, 20 points per stand
35	McIntosh 1972	Catskill Mountains--Stand 78	Point-quarter method, 20 points per stand
35	McIntosh 1972	Catskill Mountains--Stand 81	Point-quarter method, 20 points per stand
35	McIntosh 1972	Catskill Mountains--Stand 104	Point-quarter method, 20 points per stand
35	McIntosh 1972	Catskill Mountains--Stand 106	Point-quarter method, 20 points per stand
36	Messier and Bellefleur 1988	Duchesnay Experimental Forest	314-m^2 plots
37	Milfred et al. 1967	Menominee County--Stand #7	Study areas 0.40-0.81 ha in size

(Table 19 continued on next page)

(Table 19 continued)

Map Key	Source/Date	Stand	Sampling Methods
37	Milfred et al. 1967	Menominee County--Stand #19	Study areas 0.40-0.81 ha in size
38	Mladenoff and Howell 1980	Gogebic Iron Range--sugar maple-dominated	Presettlement vegetation using 1856-67 Land Survey notes
38	Mladenoff and Howell 1980	Gogebic Iron Range--yellow birch-dominated	Presettlement vegetation using 1856-67 Land Survey notes
39	Mroz et al. 1985	McCormick Experimental Forest Natural Area	5 .08-ha plots, 10 sugar maples cut for age, biomass, and total height
39	Mroz et al. 1985	Upper Peninsula/Dukes	5 .08-ha plots, 10 sugar maples cut for age, biomass, and total height
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 2	} 66 15 m x 30 m plots within 11 upland ecosystems
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 4	}
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 5	}
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 7	}
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 11	}
41	Russell 1953	Double Springs	1 10 m x 50 m plot
41	Russell 1953	Unspecified (4 beech gaps)	12 10 m x 10 m plots, 1 10 m x 30 m plot
42	Selva et al. 1989	Hedgehog Mountain	Method of canopy cover estimation unspecified
42	Selva et al. 1989	Morrison Mountain	Method of canopy cover estimation unspecified
43	Tritton 1980	Charcoal Hearth	3 100-m line transects
44	Tubbs 1977	Upper Peninsula/Dukes--tract before cutting in 1938	Unspecified; data collected before stand received first cutting in 1938.
44	Tubbs 1977	Upper Peninsula/Dukes--virgin tract	Unspecified; data collected in 1929.
45	Vogelmann et al. 1985	Camel's Hump--1965	40 3.0 m x 30.5 m plots
45	Vogelmann et al. 1985	Camel's Hump--1979	40 3.0 m x 30.5 m plots
45	Vogelmann et al. 1985	Camel's Hump--1983	40 3.0 m x 30.5 m plots
46	Wood 1975	Jefferson Notch	Quarter-point method, 6 points

[1] Number and size of strips used in each locality are unspecified.

Table 20.—*Density of live trees ≥10, ≥50, and ≥70 cm for northern hardwood old-growth study sites. For other minimum sizes, the density is listed under "≥X cm", with the minimum size for tallying trees given as "Min Diam X (cm)"*

			Live Tree Density				
Map Key	Source/Date	Stand	≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X (#/ha)	Min Diam X (cm)
1	Bourdo 1956	Misery Bay					
2	Bratton 1976	Huntington Forest--Site 1					
3	Braun 1950	Unspecified				210 [1]	25
3	Braun 1950	Pittsburg Township				201 [2]	25
4	Carbonneau 1986a	Charcoal Hearth	417				
4	Carbonneau 1986a	Eagle Cliff	380				
4	Carbonneau 1986a	Mountain Pond	450				
4	Carbonneau 1986a	The Bowl	566				
4	Carbonneau 1986a	T.V. Williams	379				
5	Carbonneau 1986b	5 stands in New Hampshire					
5	Carbonneau 1986b	T.V. Williams					
6	Cogbill 1985	Big Reed Pond					
7	Crandall 1958	Great Smoky Mountains--1524 m					
7	Crandall 1958	Great Smoky Mountains--1585 m					
7	Crandall 1958	Great Smoky Mountains*--1676 m					
8	Dahir and Lorimer 1996	Little Carp River--Plot 1					
8	Dahir and Lorimer 1996	Little Carp River--Plot 2					
8	Dahir and Lorimer 1996	Little Carp River--Plot 3					
9	Dunwiddie 1993	Cold River A--Plot 1	190			120	35
9	Dunwiddie 1993	Cold River C--Plot 1	290			110	35
9	Dunwiddie 1993	Cold River E (Manning)--Plot 2	500			70	35
9	Dunwiddie 1993	Dunbar Brook--Plot 1	370			60	35
9	Dunwiddie 1993	Fife Brook--Plot 1	390			80	35
9	Dunwiddie 1993	Fife Brook--Plot 2	320			140	35
9	Dunwiddie 1993	Mt. Greylock (Money Brook)--Plot 2	370			110	35
10	Eyre and Zillgitt 1953	Upper Peninsula--East	428 [3]				
10	Eyre and Zillgitt 1953	Upper Peninsula--West	484 [3]				
10	Eyre and Zillgitt 1953	Upper Peninsula					
11	Fassett 1944	Brule River Basin					
12	Frelich and Lorimer 1991	28 stands in Upper Peninsula	210-496 [4]				
13	Goodlett 1954	Ayers Hill Quadrangle					
13	Goodlett 1954	Coudersport Quadrangle					
13	Goodlett 1954	Oleona Quadrangle					
14	Hatt et al. 1948	South Fox Island					
14	Hatt et al. 1948	South Manitou Island					
15	Hough and Forbes 1943	East Tionesta Tract					
15	Hough and Forbes 1943	Hearts Content					

(Table 20 continued on next page)

(Table 20 continued)

Map Key	Source/Date	Stand	Live Tree Density ≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X (#/ha)	Min Diam X (cm)
16	Hudson et al. 1986	Little Bigelow					
17	Kittredge 1934	Star Island--pine to hardwood transition				1,322	2.54
18	Leak 1973	The Bowl	566[6]	46[6]	8[6]	57,193	all trees
18	Leak 1973	Bartlett Experimental Forest--Compartment 26	580[5]	50[5]	5[5]	107,605	all trees
19	Leak 1974	The Bowl					
20	Leak 1985a	The Bowl					
20	Leak 1985a	Mountain Pond North					
20	Leak 1985a	Mountain Pond South					
20	Leak 1985a	T.V. Williams					
21	Leak 1985b	The Bowl					
22	Leak 1987a	The Bowl					
22	Leak 1987a	Mountain Pond North					
22	Leak 1987a	T.V. Williams					
23	Leak 1987b	Bartlett--fine till - 450 m					
23	Leak 1987b	Bartlett--fine till - 575 m					
23	Leak 1987b	Bartlett--coarse washed till - 425 m					
23	Leak 1987b	Bartlett--coarse washed till - 575 m					
24	Leak and Graber 1974	The Bowl					
24	Leak and Graber 1974	The Bowl					
25	Leopold et al. 1988	Ampersand Mountain 3				430	5
25	Leopold et al. 1988	Baldwin Hill				}623[6]	}5
25	Leopold et al. 1988	Kildare				}	}
25	Leopold et al. 1988	McKenzie Mountain				}	}
26	Leverett 1991	6 stands in western Massachusetts					
26	Leverett 1991	Cold River					
27	Lutz 1930a	Hearts Content					
28	Maine Critical Areas Program 1983b	Beech Hill					
28	Maine Critical Areas Program 1983b	Big Reed Hardwoods					
28	Maine Critical Areas Program 1983b	Cobbosseecontee					
28	Maine Critical Areas Program 1983b	Hafey Hardwoods					
28	Maine Critical Areas Program 1983b	Haystack Mountain					
28	Maine Critical Areas Program 1983b	Lunksoos Mountain Hardwoods	470				
28	Maine Critical Areas Program 1983b	Mahoosuc Notch					
28	Maine Critical Areas Program 1983b	Musquacook Hardwoods	490				
28	Maine Critical Areas Program 1983b	Pump Handle					
28	Maine Critical Areas Program 1983b	Rockport					
28	Maine Critical Areas Program 1983b	Yankeetuladi Hardwoods	610				

(Table 20 continued on next page)

(Table 20 continued)

Map Key	Source/Date	Stand	Live Tree Density ≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X (#/ha)	Min Diam X (cm)
29	Maine's Critical Areas Program 1985	Beech Hill					
29	Maine's Critical Areas Program 1985	Cobbosseecontee					
29	Maine's Critical Areas Program 1985	Day Mountain					
29	Maine's Critical Areas Program 1985	Hafey					
29	Maine's Critical Areas Program 1985	Lunksoos					
29	Maine's Critical Areas Program 1985	Mount Philip					
29	Maine's Critical Areas Program 1985	Musquacook					
29	Maine's Critical Areas Program 1985	Pump Handle					
29	Maine's Critical Areas Program 1985	Rockport					
29	Maine's Critical Areas Program 1985	Yankeetuladi					
30	Maine State Planning Office 1986	Little Bigelow					
31	Maissurow 1941	22 stands in Wisconsin, Michigan					
32	Martin 1977	The Bowl--entire watershed					
32	Martin 1977	The Bowl--Area I (West Branch Watershed)					
32	Martin 1977	The Bowl--Area II (West Branch Watershed)					
32	Martin 1977	The Bowl--Area III (East Branch Watershed)					
32	Martin 1977	The Bowl--Area IV (East Branch Watershed)					
33	Martin 1979	The Bowl					
34	McGee in prep (dissertation)	Ampersand Mountain	380	85	15		
34	McGee in prep (dissertation)	Catlin Lake (Huntington Forest)	415	55	5		
34	McGee in prep (dissertation)	Gill Brook (Ausable Club)	405	55	20		
34	McGee in prep (dissertation)	Mason Lake	370	55	15		
34	McGee in prep (dissertation)	Moose Mountain	405	70	20		
34	McGee in prep (dissertation)	Sucker Brook	470	30	15		
34	McGee in prep (dissertation)	Whalestail Mountain	345	60	20		
35	McIntosh 1972	Catskill Mountains--9 stands listed below					
35	McIntosh 1972	Catskill Mountains--Stand 37	667				
35	McIntosh 1972	Catskill Mountains--Stand 38	573				
35	McIntosh 1972	Catskill Mountains--Stand 48	719				
35	McIntosh 1972	Catskill Mountains--Stand 61	623				
35	McIntosh 1972	Catskill Mountains--Stand 63	801				
35	McIntosh 1972	Catskill Mountains--Stand 78	702				
35	McIntosh 1972	Catskill Mountains--Stand 81	610				
35	McIntosh 1972	Catskill Mountains--Stand 104	907				
35	McIntosh 1972	Catskill Mountains--Stand 106	813				
36	Messier and Bellefleur 1988	Duchesnay Experimental Forest				200-500	5
37	Milfred et al. 1967	Menominee County--Stand #7			25	390	12.7

(Table 20 continued on next page)

(Table 20 continued)

Map Key	Source/Date	Stand	Live Tree Density ≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X (#/ha)	Min Diam X (cm)
37	Milfred et al. 1967	Menominee County--Stand #19			15	420	12.7
38	Mladenoff and Howell 1980	Gogebic Iron Range--sugar maple-dominated				548	unspecified
38	Mladenoff and Howell 1980	Gogebic Iron Range--yellow birch-dominated					
39	Mroz et al. 1985	McCormick Experimental Forest Natural Area				492	3.8
39	Mroz et al. 1985	Upper Peninsula/Dukes				542	3.8
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 2					
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 4					
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 5					
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 7					
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 11					
41	Russell 1953	Double Springs				2,280	2.54
41	Russell 1953	Unspecified (4 beech gaps)				880 [7]	2.54
42	Selva et al. 1989	Hedgehog Mountain					
42	Selva et al. 1989	Morrison Mountain					
43	Tritton 1980	Charcoal Hearth					
44	Tubbs 1977	Upper Peninsula/Dukes--tract before cutting in 1938		61	~15 [8]	318	12.7
44	Tubbs 1977	Upper Peninsula/Dukes--virgin tract					
45	Vogelmann et al. 1985	Camel's Hump--1965				2,045	2
45	Vogelmann et al. 1985	Camel's Hump--1979				1,149	2
45	Vogelmann et al. 1985	Camel's Hump--1983				1,205	2
46	Wood 1975	Jefferson Notch				618	unspecified

[1] Mean value for 3.2-ha area sampled in 3 counties; data adapted from Zon and Scholz (1929).

[2] Mean value for 4.9-ha area sampled, data adapted from Chittenden (1905).

[3] Merchantable stems.

[4] Average density >10 cm is 374.

[5] All diameters were measured above the root collar.

[6] Values apply to Baldwin Hill, Killdare, and McKenzie Mountain combined.

[7] Mean value for 4 beech gaps (stands).

[8] Value from interpolation.

Table 21.—*Basal area of live trees ≥10, ≥50, and ≥70 cm for northern hardwood old-growth study sites. For other minimum sizes the basal area is listed under "≥X cm", with the minimum size for tallying trees given as "Min Diam X (cm)".*

			Live Tree Basal Area				
Map Key	Source/Date	Stand	≥10 cm (m^2/ha)	≥50 cm (m^2/ha)	≥70 cm (m^2/ha)	≥X (m^2/ha)	Min Diam X (cm)
1	Bourdo 1956	Misery Bay					
2	Bratton 1976	Huntington Forest--Site 1					
3	Braun 1950	Unspecified					
3	Braun 1950	Pittsburg Township					
4	Carbonneau 1986a	Charcoal Hearth	25.7				
4	Carbonneau 1986a	Eagle Cliff	43.3				
4	Carbonneau 1986a	Mountain Pond	37.6				
4	Carbonneau 1986a	The Bowl	28.2				
4	Carbonneau 1986a	T.V. Williams	27.7				
5	Carbonneau 1986b	5 stands in New Hampshire					
5	Carbonneau 1986b	T.V. Williams					
6	Cogbill 1985	Big Reed Pond				26.5	unspecified
7	Crandall 1958	Great Smoky Mountains--1524 m				28.0[1]	2.54
7	Crandall 1958	Great Smoky Mountains--1585 m				23.9[1]	2.54
7	Crandall 1958	Great Smoky Mountains--1676 m				21.1[1]	2.54
8	Dahir and Lorimer 1996	Little Carp River--Plot 1		29.6[2]		49.2	4
8	Dahir and Lorimer 1996	Little Carp River--Plot 2		15.9[2]		40.7	4
8	Dahir and Lorimer 1996	Little Carp River--Plot 3		19.6[2]		33.9	4
9	Dunwiddie 1993	Cold River A--Plot 1	27.8			25.6	35
9	Dunwiddie 1993	Cold River C--Plot 1	37.4			30.2	35
9	Dunwiddie 1993	Cold River E (Manning)--Plot 2	42.1			27.6	35
9	Dunwiddie 1993	Dunbar Brook--Plot 1	26.3			17.8	35
9	Dunwiddie 1993	Fife Brook--Plot 1	36.0			27.1	35
9	Dunwiddie 1993	Fife Brook--Plot 2	39.1			33.3	35
9	Dunwiddie 1993	Mt. Greylock (Money Brook)--Plot 2	30.1			24.5	35
10	Eyre and Zillgitt 1953	Upper Peninsula--East	26.6[3]				
10	Eyre and Zillgitt 1953	Upper Peninsula--West	31.2[3]				
10	Eyre and Zillgitt 1953	Upper Peninsula	33.1				
11	Fassett 1944	Brule River Basin					
12	Frelich and Lorimer 1991	28 stands in Upper Peninsula	26.6-52.1[4]				
13	Goodlett 1954	Ayers Hill Quadrangle					
13	Goodlett 1954	Coudersport Quadrangle					
13	Goodlett 1954	Oleona Quadrangle					
14	Hatt et al. 1948	South Fox Island					
14	Hatt et al. 1948	South Manitou Island					
15	Hough and Forbes 1943	East Tionesta Tract					
15	Hough and Forbes 1943	Hearts Content					

(Table 21 continued on next page)

(Table 21 continued)

Map Key	Source/Date	Stand	Live Tree Basal Area ≥10 cm (m^2/ha)	≥50 cm (m^2/ha)	≥70 cm (m^2/ha)	≥X (m^2/ha)	Min Diam X (cm)
16	Hudson et al. 1986	Little Bigelow					
17	Kittredge 1934	Star Island--pine to hardwood transition					
18	Leak 1973	The Bowl					
18	Leak 1973	Bartlett Experimental Forest--Compartment 26					
19	Leak 1974	The Bowl					
20	Leak 1985a	The Bowl				28.2	15
20	Leak 1985a	Mountain Pond North				28.2	15
20	Leak 1985a	Mountain Pond South				27.3	15
20	Leak 1985a	T.V. Williams				23.0	15
21	Leak 1985b	The Bowl					
22	Leak 1987a	The Bowl				30.6	5
22	Leak 1987a	Mountain Pond North				30.6	5
22	Leak 1987a	T.V. Williams				25.3	5
23	Leak 1987b	Bartlett--fine till - 450 m				29.5	11.5
23	Leak 1987b	Bartlett--fine till - 575 m				28.9	11.5
23	Leak 1987b	Bartlett--coarse washed till - 425 m				27.4	11.5
23	Leak 1987b	Bartlett--coarse washed till - 575 m				25.2	11.5
24	Leak and Graber 1974	The Bowl					
24	Leak and Graber 1974	The Bowl					
25	Leopold et al. 1988	Ampersand Mountain 3				37.6	5
25	Leopold et al. 1988	Baldwin Hill				}27.5 [5]	5
25	Leopold et al. 1988	Kildare				}	
25	Leopold et al. 1988	McKenzie Mountain				}	
26	Leverett 1991	6 stands in western Massachusetts					
26	Leverett 1991	Cold River					
27	Lutz 1930a	Hearts Content					
28	Maine Critical Areas Program 1983b	Beech Hill					
28	Maine Critical Areas Program 1983b	Big Reed Hardwoods					
28	Maine Critical Areas Program 1983b	Cobbosseecontee					
28	Maine Critical Areas Program 1983b	Hafey Hardwoods					
28	Maine Critical Areas Program 1983b	Haystack Mountain					
28	Maine Critical Areas Program 1983b	Lunksoos Mountain Hardwoods				27.7	unspecified
28	Maine Critical Areas Program 1983b	Mahoosuc Notch					
28	Maine Critical Areas Program 1983b	Musquacook Hardwoods				27.3	unspecified
28	Maine Critical Areas Program 1983b	Pump Handle					
28	Maine Critical Areas Program 1983b	Rockport					
28	Maine Critical Areas Program 1983b	Yankeetuladi Hardwoods				21.0	2.54

(Table 21 continued on next page)

(Table 21 continued)

			Live Tree Basal Area				
Map Key	Source/Date	Stand	≥10 cm (m^2/ha)	≥50 cm (m^2/ha)	≥70 cm (m^2/ha)	≥X (m^2/ha)	Min Diam X (cm)
29	Maine's Critical Areas Program 1985	Beech Hill					
29	Maine's Critical Areas Program 1985	Cobbosseecontee					
29	Maine's Critical Areas Program 1985	Day Mountain					
29	Maine's Critical Areas Program 1985	Hafey					
29	Maine's Critical Areas Program 1985	Lunksoos					
29	Maine's Critical Areas Program 1985	Mount Philip					
29	Maine's Critical Areas Program 1985	Musquacook					
29	Maine's Critical Areas Program 1985	Pump Handle					
29	Maine's Critical Areas Program 1985	Rockport					
29	Maine's Critical Areas Program 1985	Yankeetuladi					
30	Maine State Planning Office 1986	Little Bigelow					
31	Maissurow 1941	22 stands in Wisconsin, Michigan					
32	Martin 1977	The Bowl--entire watershed				28.2 [6]	unspecified
32	Martin 1977	The Bowl--Area I (West Branch Watershed)				29.1	unspecified
32	Martin 1977	The Bowl--Area II (West Branch Watershed)				29.9	unspecified
32	Martin 1977	The Bowl--Area III (East Branch Watershed)				27.2	unspecified
32	Martin 1977	The Bowl--Area IV (East Branch Watershed)				27.0	unspecified
33	Martin 1979	The Bowl				28.0 [7]	unspecified
34	McGee in prep (dissertation)	Ampersand Mountain	39.6	27.3	6.8		
34	McGee in prep (dissertation)	Catlin Lake (Huntington Forest)	28.3	15.7	2.1		
34	McGee in prep (dissertation)	Gill Brook (Ausable Club)	31.2	17.0	8.6		
34	McGee in prep (dissertation)	Mason Lake	33.2	21.5	11.6		
34	McGee in prep (dissertation)	Moose Mountain	39.0	24.4	10.1		
34	McGee in prep (dissertation)	Sucker Brook	31.9	12.7	8.2		
34	McGee in prep (dissertation)	Whalestail Mountain	38.2	21.5	10.3		
35	McIntosh 1972	Catskill Mountains--9 stands listed below					
35	McIntosh 1972	Catskill Mountains--Stand 37	69.6				
35	McIntosh 1972	Catskill Mountains--Stand 38	48.2				
35	McIntosh 1972	Catskill Mountains--Stand 48	72.8				
35	McIntosh 1972	Catskill Mountains--Stand 61	75.3				
35	McIntosh 1972	Catskill Mountains--Stand 63	61.1				
35	McIntosh 1972	Catskill Mountains--Stand 78	69.8				
35	McIntosh 1972	Catskill Mountains--Stand 81	67.3				
35	McIntosh 1972	Catskill Mountains--Stand 104	70.9				
35	McIntosh 1972	Catskill Mountains--Stand 106	45.7				
36	Messier and Bellefleur 1988	Duchesnay Experimental Forest					
37	Milfred et al. 1967	Menominee County--Stand #7					

(Table 21 continued on next page)

(Table 21 continued)

Map Key	Source/Date	Stand	Live Tree Basal Area				Min Diam X
			$\geq$10 cm (m^2/ha)	$\geq$50 cm (m^2/ha)	$\geq$70 cm (m^2/ha)	$\geq$X (m^2/ha)	X (cm)
37	Milfred et al. 1967	Menominee County--Stand #19					
38	Mladenoff and Howell 1980	Gogebic Iron Range--sugar maple-dominated				47.1	unspecified
38	Mladenoff and Howell 1980	Gogebic Iron Range--yellow birch-dominated					
39	Mroz et al. 1985	McCormick Experimental Forest Natural Area				43.2	3.8
39	Mroz et al. 1985	Upper Peninsula/Dukes				34.4	3.8
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 2	34.5				
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 4	38.9				
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 5	38.8				
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 7	32.0				
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 11	35.9				
41	Russell 1953	Double Springs					
41	Russell 1953	Unspecified (4 beech gaps)				36.9 [8]	unspecified
42	Selva et al. 1989	Hedgehog Mountain					
42	Selva et al. 1989	Morrison Mountain					
43	Tritton 1980	Charcoal Hearth					
44	Tubbs 1977	Upper Peninsula/Dukes--tract before cutting in 1938					
44	Tubbs 1977	Upper Peninsula/Dukes--virgin tract					
45	Vogelmann et al. 1985	Camel's Hump--1965				37.8	2
45	Vogelmann et al. 1985	Camel's Hump--1979				32.2	2
45	Vogelmann et al. 1985	Camel's Hump--1983				30.1	2
46	Wood 1975	Jefferson Notch					

[1] Results are organized by vegetation type and elevation rather than by stand.

[2] Basal area is for trees >46 cm.

[3] Merchantable stems.

[4] Average basal area >10 cm is 37.5.

[5] Values apply to Baldwin Hill, Killdare, and McKenzie Mountain combined.

[6] Values are from the entire 607-ha watershed, which contains conifer-hardwood stands at elevations of 750-915 m.

[7] Values are from the entire 607-ha watershed.

[8] Mean value for 4 beech gaps.

Table 22.—*Average and maximum tree age by species for northern hardwood old-growth study sites. Abbreviations for "Other" tree species are as follows: Bass, American basswood; BC, black cherry; H, eastern hemlock; RO, red oak; RP, red pine; RS, red spruce; SM, sugar maple; WAsh, white ash; WC, northern white-cedar; WP, eastern white pine.*

Map Key	Source/Date	Stand	Average Age (yr)	Maximum Tree Age (yr)					
				Sugar Maple	Yellow Birch	American Beech	Red Maple	Eastern Hemlock	Other
1	Bourdo 1956	Misery Bay							
2	Bratton 1976	Huntington Forest--Site 1							
3	Braun 1950	Unspecified							
3	Braun 1950	Pittsburg Township							
4	Carbonneau 1986a	Charcoal Hearth							
4	Carbonneau 1986a	Eagle Cliff							
4	Carbonneau 1986a	Mountain Pond							
4	Carbonneau 1986a	The Bowl							
4	Carbonneau 1986a	T.V. Williams							
5	Carbonneau 1986b	5 stands in New Hampshire		250-350 [1]	250-350 [1]				
5	Carbonneau 1986b	T.V. Williams							
6	Cogbill 1985	Big Reed Pond		150+					WC-180+, RS 161+ [2]
7	Crandall 1958	Great Smoky Mountains--1524 m							
7	Crandall 1958	Great Smoky Mountains--1585 m							
7	Crandall 1958	Great Smoky Mountains--1676 m							
8	Dahir and Lorimer 1996	Little Carp River--Plot 1	[3]						
8	Dahir and Lorimer 1996	Little Carp River--Plot 2	[4]						
8	Dahir and Lorimer 1996	Little Carp River--Plot 3	[5]						
9	Dunwiddie 1993	Cold River A--Plot 1		124		177			
9	Dunwiddie 1993	Cold River C--Plot 1		214					WAsh-98
9	Dunwiddie 1993	Cold River E (Manning)--Plot 2		170					
9	Dunwiddie 1993	Dunbar Brook--Plot 1		119					
9	Dunwiddie 1993	Fife Brook--Plot 1		138					
9	Dunwiddie 1993	Fife Brook--Plot 2		177					
9	Dunwiddie 1993	Mt. Greylock (Money Brook)--Plot 2		207					WAsh-141
10	Eyre and Zillgitt 1953	Upper Peninsula--East							
10	Eyre and Zillgitt 1953	Upper Peninsula--West							
10	Eyre and Zillgitt 1953	Upper Peninsula			320+			400+	
11	Fassett 1944	Brule River Basin							
12	Frelich and Lorimer 1991	28 stands in Upper Peninsula	76-304 [6]						
13	Goodlett 1954	Ayers Hill Quadrangle		100+ [7]					
13	Goodlett 1954	Coudersport Quadrangle		250 [7]					
13	Goodlett 1954	Oleona Quadrangle							
14	Hatt et al. 1948	South Fox Island							
14	Hatt et al. 1948	South Manitou Island							
15	Hough and Forbes 1943	East Tionesta Tract		420 [8]	366 [8]	366 [8]	310 [8]		BC-258 [8]
15	Hough and Forbes 1943	Hearts Content				290 [9]	290 [9]		

(Table 22 continued on next page)

(Table 22 continued)

Map Key	Source/Date	Stand	Average Age (yr)	Maximum Tree Age (yr): Sugar Maple	Yellow Birch	American Beech	Red Maple	Eastern Hemlock	Other
16	Hudson et al. 1986	Little Bigelow		150 [10]	150 [10]	150 [10]			
17	Kittredge 1934	Star Island--pine to hardwood transition							WP/RP-300+
18	Leak 1973	The Bowl							
18	Leak 1973	Bartlett Experimental Forest--Compartment 26							
19	Leak 1974	The Bowl		170 [11]	250 [11]	230 [11]			RS-230 [11]
20	Leak 1985a	The Bowl							
20	Leak 1985a	Mountain Pond North							
20	Leak 1985a	Mountain Pond South							
20	Leak 1985a	T.V. Williams							
21	Leak 1985b	The Bowl		175 [12]					
22	Leak 1987a	The Bowl							
22	Leak 1987a	Mountain Pond North							
22	Leak 1987a	T.V. Williams							
23	Leak 1987b	Bartlett--fine till - 450 m							
23	Leak 1987b	Bartlett--fine till - 575 m							
23	Leak 1987b	Bartlett--coarse washed till - 425 m							
23	Leak 1987b	Bartlett--coarse washed till - 575 m							
24	Leak and Graber 1974	The Bowl			235 [13]	180 [13]			
24	Leak and Graber 1974	The Bowl			205 [13]	150 [13]			
25	Leopold et al. 1988	Ampersand Mountain 3							
25	Leopold et al. 1988	Baldwin Hill							
25	Leopold et al. 1988	Kildare							
25	Leopold et al. 1988	McKenzie Mountain							
26	Leverett 1991	6 stands in western Massachusetts						400+	
26	Leverett 1991	Cold River						425-475 [14]	
27	Lutz 1930a	Hearts Content							
28	Maine Critical Areas Program 1983b	Beech Hill		160		134+			RO-158+
28	Maine Critical Areas Program 1983b	Big Reed Hardwoods							RS-90-150
28	Maine Critical Areas Program 1983b	Cobbosseecontee		189-200				189-200	RO-189-200; WP215
28	Maine Critical Areas Program 1983b	Hafey Hardwoods							
28	Maine Critical Areas Program 1983b	Haystack Mountain							
28	Maine Critical Areas Program 1983b	Lunksoos Mountain Hardwoods		238+					
28	Maine Critical Areas Program 1983b	Mahoosuc Notch							
28	Maine Critical Areas Program 1983b	Musquacook Hardwoods		190+	175-200	105-115			
28	Maine Critical Areas Program 1983b	Pump Handle	113 [15]						
28	Maine Critical Areas Program 1983b	Rockport		101-173	101-173	101-173			
28	Maine Critical Areas Program 1983b	Yankeetuladi Hardwoods		233+					

(Table 22 continued on next page)

(Table 22 continued)

Map Key	Source/Date	Stand	Average Age (yr)	Maximum Tree Age (yr)					
				Sugar Maple	Yellow Birch	American Beech	Red Maple	Eastern Hemlock	Other
29	Maine's Critical Areas Program 1985	Beech Hill							130[16]
29	Maine's Critical Areas Program 1985	Cobbosseecontee							200[16]
29	Maine's Critical Areas Program 1985	Day Mountain							130-150[16]
29	Maine's Critical Areas Program 1985	Hafey							275[16]
29	Maine's Critical Areas Program 1985	Lunksoos							250+[16]
29	Maine's Critical Areas Program 1985	Mount Philip							150[16]
29	Maine's Critical Areas Program 1985	Musquacook							200[16]
29	Maine's Critical Areas Program 1985	Pump Handle	113[16]						
29	Maine's Critical Areas Program 1985	Rockport				173			
29	Maine's Critical Areas Program 1985	Yankeetuladi							233[16]
30	Maine State Planning Office 1986	Little Bigelow	150[16]						
31	Maissurow 1941	22 stands in Wisconsin, Michigan		291[17]	249[17]			245[17]	Bass-156; WP-350[17]
32	Martin 1977	The Bowl--entire watershed							
32	Martin 1977	The Bowl--Area I (West Branch Watershed)							
32	Martin 1977	The Bowl--Area II (West Branch Watershed)							
32	Martin 1977	The Bowl--Area III (East Branch Watershed)							
32	Martin 1977	The Bowl--Area IV (East Branch Watershed)							
33	Martin 1979	The Bowl							
34	McGee in prep (dissertation)	Ampersand Mountain	SM-175[18]						
34	McGee in prep (dissertation)	Catlin Lake (Huntington Forest)	SM-165[19]	218[20]					
34	McGee in prep (dissertation)	Gill Brook (Ausable Club)	SM-115, H-274[21]						RS-254[20]
34	McGee in prep (dissertation)	Mason Lake	157[19]					247[20]	WAsh-157[20]
34	McGee in prep (dissertation)	Moose Mountain	SM-142[19]						
34	McGee in prep (dissertation)	Sucker Brook	SM-173[18]		250[20]				RS-141[20]
34	McGee in prep (dissertation)	Whalestail Mountain	SM-125[18]						RS-176[20]
35	McIntosh 1972	Catskill Mountains--9 stands listed below		200[18]		260[18]		300[18]	
35	McIntosh 1972	Catskill Mountains--Stand 37							
35	McIntosh 1972	Catskill Mountains--Stand 38							
35	McIntosh 1972	Catskill Mountains--Stand 48							
35	McIntosh 1972	Catskill Mountains--Stand 61							
35	McIntosh 1972	Catskill Mountains--Stand 63							
35	McIntosh 1972	Catskill Mountains--Stand 78							
35	McIntosh 1972	Catskill Mountains--Stand 81							
35	McIntosh 1972	Catskill Mountains--Stand 104							
35	McIntosh 1972	Catskill Mountains--Stand 106							
36	Messier and Bellefleur 1988	Duchesnay Experimental Forest							185
37	Milfred et al. 1967	Menominee County--Stand #7							

(Table 22 continued on next page)

(Table 22 continued)

Map Key	Source/Date	Stand	Average Age (yr)	Maximum Tree Age (yr)					
				Sugar Maple	Yellow Birch	American Beech	Red Maple	Eastern Hemlock	Other
37	Milfred et al. 1967	Menominee County--Stand #19							130
38	Mladenoff and Howell 1980	Gogebic Iron Range--sugar maple-dominated							
38	Mladenoff and Howell 1980	Gogebic Iron Range--yellow birch-dominated							
39	Mroz et al. 1985	McCormick Experimental Forest Natural Area		141[22]					
39	Mroz et al. 1985	Upper Peninsula/Dukes		135[22]					
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 2							
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 4							
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 5							
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 7							
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 11							
41	Russell 1953	Double Springs							
41	Russell 1953	Unspecified (4 beech gaps)							
42	Selva et al. 1989	Hedgehog Mountain							
42	Selva et al. 1989	Morrison Mountain							
43	Tritton 1980	Charcoal Hearth							200+
44	Tubbs 1977	Upper Peninsula/Dukes--tract before cutting in 1938							
44	Tubbs 1977	Upper Peninsula/Dukes--virgin tract		363					
45	Vogelmann et al. 1985	Camel's Hump--1965							
45	Vogelmann et al. 1985	Camel's Hump--1979							
45	Vogelmann et al. 1985	Camel's Hump--1983							
46	Wood 1975	Jefferson Notch							

[1] Values apply to either sugar maple or yellow birch in five stands.

[2] Not necessarily specific to northern hardwood stands, may apply to other forest types within Big Reed Pond.

[3] Percent upper canopy trees ≥200 years is 50%.

[4] Percent upper canopy trees ≥200 years is 43%.

[5] Percent upper canopy trees ≥200 years is 54%.

[6] Average age was 172 for sugar maple; 140 for eastern hemlock and yellow birch.

[7] Approximate count of rings on a single stump of sugar maple and may not represent true stand maximum.

[8] Maximum ages based on plots within beech-maple forest at 573 m and additional plots within several other forest types at various elevations.

[9] Maximum ages estimated from graph of age distributions at Heart's Content; precise forest types unspecified.

[10] Age of stand, may apply to sugar maple, yellow birch or American beech.

[11] Ages estimated from plots of number of trees/ha in logarithms vs. 20-yr age class.

[12] Estimated from plot of age vs. diameter. Values may not represent maximum age of sugar maple for the stand.

[13] Values estimated from plots of age vs. elevation for American beech and yellow birch.

[14] Estimated age of a single fallen eastern hemlock.

[15] Average for American beech and sugar maple.

[16] Species unspecified.

[17] Maximum ages from a 0.1-ha plot, a 200 m transect, and additional borings of oldest trees.

[18] Based on 5 tree cores.

(Table 22 continued on next page)

(Table 22 continued)

[19] Based on 4 tree cores.
[20] Based on 1 tree core.
[21] Based on 2 tree cores.
[22] Maximum ages for felled trees, not necessarily maximum ages for the stand.

Table 23.—*Maximum tree diameter by species, and percentage of the tree canopy in gaps for northern hardwood old-growth study sites. Abbreviations for other tree species are as follows: RP, red pine; RS, red spruce; WAsh, white ash; WP, eastern white pine.*

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm) Sugar Maple	Yellow Birch	American Basswood	American Beech	Elm spp.	Red Maple	N. Red Oak	Eastern Hemlock	Other	Canopy Gaps (%)
1	Bourdo 1956	Misery Bay	76	76						76		
2	Bratton 1976	Huntington Forest--Site 1									65+	
3	Braun 1950	Unspecified										
3	Braun 1950	Pittsburg Township										
4	Carbonneau 1986a	Charcoal Hearth	}55 [1]	}85 [1]		}55 [1]						
4	Carbonneau 1986a	Eagle Cliff	}	}		}						
4	Carbonneau 1986a	Mountain Pond	}95 [2]	}85 [2]		}55 [2]						
4	Carbonneau 1986a	The Bowl	}	}		}						
4	Carbonneau 1986a	T.V. Williams	85 [3]	75 [3]		65 [3]		45 [3]				
5	Carbonneau 1986b	5 stands in New Hampshire	79-94 [4]	79-94 [4]								
5	Carbonneau 1986b	T.V. Williams		112								
6	Cogbill 1985	Big Reed Pond										
7	Crandall 1958	Great Smoky Mountains--1524 m		76-89 [5]		25-38 [5]						
7	Crandall 1958	Great Smoky Mountains--1585 m		64-76 [5]								
7	Crandall 1958	Great Smoky Mountains--1676 m				38-51 [5]						
8	Dahir and Lorimer 1996	Little Carp River--Plot 1									98	
8	Dahir and Lorimer 1996	Little Carp River--Plot 2									89	
8	Dahir and Lorimer 1996	Little Carp River--Plot 3									86	
9	Dunwiddie 1993	Cold River A--Plot 1	65	52		56					WAsh-58	
9	Dunwiddie 1993	Cold River C--Plot 1	71			31		60			WAsh-67	
9	Dunwiddie 1993	Cold River E (Manning)--Plot 2	92			29				72		
9	Dunwiddie 1993	Dunbar Brook--Plot 1	87	30		51					WAsh-37	
9	Dunwiddie 1993	Fife Brook--Plot 1	103			74						
9	Dunwiddie 1993	Fife Brook--Plot 2	82			72						
9	Dunwiddie 1993	Mt. Greylock (Money Brook)--Plot 2	65	60		20					WAsh-85	
10	Eyre and Zillgitt 1953	Upper Peninsula--East	86	86	81	71	107			102	112	
10	Eyre and Zillgitt 1953	Upper Peninsula--West	81	86	81		97			107		
10	Eyre and Zillgitt 1953	Upper Peninsula										
11	Fassett 1944	Brule River Basin	38 [6]									
12	Frelich and Lorimer 1991	28 stands in Upper Peninsula										
13	Goodlett 1954	Ayers Hill Quadrangle	102 [7]									
13	Goodlett 1954	Coudersport Quadrangle	79									
13	Goodlett 1954	Oleona Quadrangle	76			61+						
14	Hatt et al. 1948	South Fox Island									76+	
14	Hatt et al. 1948	South Manitou Island									122	
15	Hough and Forbes 1943	East Tionesta Tract										
15	Hough and Forbes 1943	Hearts Content										

(Table 23 continued on next page)

(Table 23 continued)

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm) Sugar Maple	Yellow Birch	American Basswood	American Beech	Elm spp.	Red Maple	N. Red Oak	Eastern Hemlock	Other	Canopy Gaps (%)
16	Hudson et al. 1986	Little Bigelow										
17	Kittredge 1934	Star Island--pine to hardwood transition	36		13			18	36		WP-107; RP-79	
18	Leak 1973	The Bowl	80-90 [8]	90-95 [8]		50-60 [8]		10-20 [8]			RS-60-70 [8]	
18	Leak 1973	Bartlett Experimental Forest--Compartment 26	50-60 [8]	50-60 [8]		60-70 [8]		40-50 [8]		40-50 [8]	RS-40-50 [8]	
19	Leak 1974	The Bowl										
20	Leak 1985a	The Bowl									91 [9]	
20	Leak 1985a	Mountain Pond North									91 [9]	
20	Leak 1985a	Mountain Pond South									97 [9]	
20	Leak 1985a	T.V. Williams									91 [9]	
21	Leak 1985b	The Bowl	56 [10]									
22	Leak 1987a	The Bowl	86	91		61		36		66	RS-61	
22	Leak 1987a	Mountain Pond North	91	76	66	66		20			RS-36	
22	Leak 1987a	T.V. Williams	91	81		71		71		41		
23	Leak 1987b	Bartlett--fine till - 450 m										
23	Leak 1987b	Bartlett--fine till - 575 m										
23	Leak 1987b	Bartlett--coarse washed till - 425 m										
23	Leak 1987b	Bartlett--coarse washed till - 575 m										
24	Leak and Graber 1974	The Bowl	74	76		53						
24	Leak and Graber 1974	The Bowl	60	68		42					RS-66	
25	Leopold et al. 1988	Ampersand Mountain 3	97									
25	Leopold et al. 1988	Baldwin Hill		}75 [11]								
25	Leopold et al. 1988	Kildare		}								
25	Leopold et al. 1988	McKenzie Mountain		}								
26	Leverett 1991	6 stands in western Massachusetts										
26	Leverett 1991	Cold River										
27	Lutz 1930a	Hearts Content										
28	Maine Critical Areas Program 1983b	Beech Hill	78		36	56			72			
28	Maine Critical Areas Program 1983b	Big Reed Hardwoods	69	76		66					RS-76	
28	Maine Critical Areas Program 1983b	Cobbosseecontee	74			58			86	84	WP-102	
28	Maine Critical Areas Program 1983b	Hafey Hardwoods	53			15						
28	Maine Critical Areas Program 1983b	Haystack Mountain	71	33		33						
28	Maine Critical Areas Program 1983b	Lunksoos Mountain Hardwoods	84	74	61	46					RS-56	
28	Maine Critical Areas Program 1983b	Mahoosuc Notch	46	66							RS-41	
28	Maine Critical Areas Program 1983b	Musquacook Hardwoods	61	38		38						10
28	Maine Critical Areas Program 1983b	Pump Handle	76									
28	Maine Critical Areas Program 1983b	Rockport	81			48			104			
28	Maine Critical Areas Program 1983b	Yankeetuladi Hardwoods	66	56		46					RS-23	10

(Table 23 continued on next page)

(Table 23 continued)

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm)									Canopy Gaps (%)
			Sugar Maple	Yellow Birch	American Basswood	American Beech	Elm spp.	Red Maple	N. Red Oak	Eastern Hemlock	Other	
29	Maine's Critical Areas Program 1985	Beech Hill										
29	Maine's Critical Areas Program 1985	Cobbosseecontee										
29	Maine's Critical Areas Program 1985	Day Mountain										
29	Maine's Critical Areas Program 1985	Hafey										
29	Maine's Critical Areas Program 1985	Lunksoos										
29	Maine's Critical Areas Program 1985	Mount Philip										
29	Maine's Critical Areas Program 1985	Musquacook										
29	Maine's Critical Areas Program 1985	Pump Handle										
29	Maine's Critical Areas Program 1985	Rockport										
29	Maine's Critical Areas Program 1985	Yankeetuladi										
30	Maine State Planning Office 1986	Little Bigelow										
31	Maissurow 1941	22 stands in Wisconsin, Michigan										
32	Martin 1977	The Bowl--entire watershed	40+ [12]	40+ [12]		40+ [12]						
32	Martin 1977	The Bowl--Area I (West Branch Watershed)										
32	Martin 1977	The Bowl--Area II (West Branch Watershed)										
32	Martin 1977	The Bowl--Area III (East Branch Watershed)										
32	Martin 1977	The Bowl--Area IV (East Branch Watershed)										
33	Martin 1979	The Bowl										
34	McGee in prep (dissertation)	Ampersand Mountain	84	57		25				38		
34	McGee in prep (dissertation)	Catlin Lake (Huntington Forest)	72	67		46					RS-52	
34	McGee in prep (dissertation)	Gill Brook (Ausable Club)										
34	McGee in prep (dissertation)	Mason Lake	83		65	39				68	WAsh-75	
34	McGee in prep (dissertation)	Moose Mountain	94	67	63	53				42		
34	McGee in prep (dissertation)	Sucker Brook	80	93		41					RS-37	
34	McGee in prep (dissertation)	Whalestail Mountain	88			44					RS-39	
35	McIntosh 1972	Catskill Mountains--9 stands listed below										
35	McIntosh 1972	Catskill Mountains--Stand 37										
35	McIntosh 1972	Catskill Mountains--Stand 38										
35	McIntosh 1972	Catskill Mountains--Stand 48										
35	McIntosh 1972	Catskill Mountains--Stand 61										
35	McIntosh 1972	Catskill Mountains--Stand 63										
35	McIntosh 1972	Catskill Mountains--Stand 78										
35	McIntosh 1972	Catskill Mountains--Stand 81										
35	McIntosh 1972	Catskill Mountains--Stand 104										
35	McIntosh 1972	Catskill Mountains--Stand 106										
36	Messier and Bellefleur 1988	Duchesnay Experimental Forest										
37	Milfred et al. 1967	Menominee County--Stand #7	70+	70+	70+		70+			32-39	70+	

(Table 23 continued on next page)

(Table 23 continued)

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm) Sugar Maple	Yellow Birch	American Basswood	American Beech	Elm spp.	Red Maple	N. Red Oak	Eastern Hemlock	Other	Canopy Gaps (%)
37	Milfred et al. 1967	Menominee County--Stand #19	55-62	47-55	70+		47-55		70+	39-47	70+	
38	Mladenoff and Howell 1980	Gogebic Iron Range--sugar maple-dominated	61[13]	66[13]	61[13]					91[13]	91[13]	
38	Mladenoff and Howell 1980	Gogebic Iron Range--yellow birch-dominated	51[13]	71[13]	36[13]					61[13]	71[13]	
39	Mroz et al. 1985	McCormick Experimental Forest Natural Area	65+	44-54							65+	
39	Mroz et al. 1985	Upper Peninsula/Dukes	65+	34-44							65+	
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 2										
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 4										
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 5										
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 7										
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 11										
41	Russell 1953	Double Springs				30					30	
41	Russell 1953	Unspecified (4 beech gaps)										
42	Selva et al. 1989	Hedgehog Mountain										15
42	Selva et al. 1989	Morrison Mountain										20-25
43	Tritton 1980	Charcoal Hearth										
44	Tubbs 1977	Upper Peninsula/Dukes--tract before cutting in 1938									114+	
44	Tubbs 1977	Upper Peninsula/Dukes--virgin tract	81									
45	Vogelmann et al. 1985	Camel's Hump--1965										
45	Vogelmann et al. 1985	Camel's Hump--1979										
45	Vogelmann et al. 1985	Camel's Hump--1983										
46	Wood 1975	Jefferson Notch		87+								

[1] Data from Charcoal Hearth and Eagle Cliff combined. Values are estimates from plots of tree density vs. d.b.h. class.

[2] Data from Mountain Pond and The Bowl combined. Values are estimates from plots of tree density vs. d.b.h. class.

[3] Values are estimates from plots of tree density vs. d.b.h. class.

[4] Values apply to either sugar maple or yellow birch in five stands.

[5] Results are organized by vegetation type and elevation rather than by stand. Thus, the link between data and a particular stand is unspecified.

[6] Represents a single witness tree, indicated on a map of witness trees by species and diameter.

[7] Size of one sugar maple stump.

[8] All diameters were measured above the root collar.

[9] Maximum diameters estimated from graph of number of trees per hectar vs. d.b.h.

[10] Estimated from plot of age vs. diameter; diameter was measured at top of root swell. Values may not represent maximum diameter of sugar maple for the stand.

[11] Values apply to Baldwin Hill, Killdare, and McKenzie Mountain combined.

[12] Values are for the entire 607-ha watershed, which contains conifer-hardwood stands at elevations of 750-915 m.

[13] Values estimated from plot of percent trees versus diameter class.

Table 24.—*Density, basal area, and minimum diameter measured for standing dead trees (snags) in northern hardwood old-growth study sites.*

			Standing Dead Trees (Snags)		
Map Key	Source/Date	Stand	Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Min Snag Diam (cm)
1	Bourdo 1956	Misery Bay			
2	Bratton 1976	Huntington Forest--Site 1			
3	Braun 1950	Unspecified			
3	Braun 1950	Pittsburg Township			
4	Carbonneau 1986a	Charcoal Hearth	33	2.7	10
4	Carbonneau 1986a	Eagle Cliff	60	5.1	10
4	Carbonneau 1986a	Mountain Pond	50	4.2	10
4	Carbonneau 1986a	The Bowl	54	4.4	10
4	Carbonneau 1986a	T.V. Williams	36	2.9	10
5	Carbonneau 1986b	5 stands in New Hampshire			
5	Carbonneau 1986b	T.V. Williams			
6	Cogbill 1985	Big Reed Pond		4.9 [1]	
7	Crandall 1958	Great Smoky Mountains--1524 m			
7	Crandall 1958	Great Smoky Mountains--1585 m			
7	Crandall 1958	Great Smoky Mountains--1676 m			
8	Dahir and Lorimer 1996	Little Carp River--Plot 1			
8	Dahir and Lorimer 1996	Little Carp River--Plot 2			
8	Dahir and Lorimer 1996	Little Carp River--Plot 3			
9	Dunwiddie 1993	Cold River A--Plot 1	20	2.1	10
9	Dunwiddie 1993	Cold River C--Plot 1	20	2.1	10
9	Dunwiddie 1993	Cold River E (Manning)--Plot 2	60	10.7	10
9	Dunwiddie 1993	Dunbar Brook--Plot 1	50	9.6	10
9	Dunwiddie 1993	Fife Brook--Plot 1	0	0	10
9	Dunwiddie 1993	Fife Brook--Plot 2	20	0.3	10
9	Dunwiddie 1993	Mt. Greylock (Money Brook)--Plot 2	10	1.3	10
10	Eyre and Zillgitt 1953	Upper Peninsula--East			
10	Eyre and Zillgitt 1953	Upper Peninsula--West			
10	Eyre and Zillgitt 1953	Upper Peninsula			
11	Fassett 1944	Brule River Basin			
12	Frelich and Lorimer 1991	28 stands in Upper Peninsula	2-26 [2]		46
13	Goodlett 1954	Ayers Hill Quadrangle			
13	Goodlett 1954	Coudersport Quadrangle			
13	Goodlett 1954	Oleona Quadrangle			
14	Hatt et al. 1948	South Fox Island			
14	Hatt et al. 1948	South Manitou Island			
15	Hough and Forbes 1943	East Tionesta Tract			
15	Hough and Forbes 1943	Hearts Content			

(Table 24 continued on next page)

(Table 24 continued)

			Standing Dead Trees (Snags)		
Map Key	Source/Date	Stand	Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Min Snag Diam (cm)
16	Hudson et al. 1986	Little Bigelow			
17	Kittredge 1934	Star Island--pine to hardwood transition			
18	Leak 1973	The Bowl			
18	Leak 1973	Bartlett Experimental Forest--Compartment 26			
19	Leak 1974	The Bowl			
20	Leak 1985a	The Bowl			
20	Leak 1985a	Mountain Pond North			
20	Leak 1985a	Mountain Pond South			
20	Leak 1985a	T.V. Williams			
21	Leak 1985b	The Bowl			
22	Leak 1987a	The Bowl			
22	Leak 1987a	Mountain Pond North			
22	Leak 1987a	T.V. Williams			
23	Leak 1987b	Bartlett--fine till - 450 m			
23	Leak 1987b	Bartlett--fine till - 575 m			
23	Leak 1987b	Bartlett--coarse washed till - 425 m			
23	Leak 1987b	Bartlett--coarse washed till - 575 m			
24	Leak and Graber 1974	The Bowl			
24	Leak and Graber 1974	The Bowl			
25	Leopold et al. 1988	Ampersand Mountain 3	70	0.78	5
25	Leopold et al. 1988	Baldwin Hill	}77[3]	}7.5[3]	}5
25	Leopold et al. 1988	Kildare	}	}	}
25	Leopold et al. 1988	McKenzie Mountain	}	}	}
26	Leverett 1991	6 stands in western Massachusetts			
26	Leverett 1991	Cold River			
27	Lutz 1930a	Hearts Content	865[4]		
28	Maine Critical Areas Program 1983b	Beech Hill			
28	Maine Critical Areas Program 1983b	Big Reed Hardwoods			
28	Maine Critical Areas Program 1983b	Cobbosseecontee			
28	Maine Critical Areas Program 1983b	Hafey Hardwoods			
28	Maine Critical Areas Program 1983b	Haystack Mountain			
28	Maine Critical Areas Program 1983b	Lunksoos Mountain Hardwoods			
28	Maine Critical Areas Program 1983b	Mahoosuc Notch			
28	Maine Critical Areas Program 1983b	Musquacook Hardwoods			
28	Maine Critical Areas Program 1983b	Pump Handle			
28	Maine Critical Areas Program 1983b	Rockport			
28	Maine Critical Areas Program 1983b	Yankeetuladi Hardwoods			

(Table 24 continued on next page)

(Table 24 continued)

Map Key	Source/Date	Stand	Standing Dead Trees (Snags)		
			Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Min Snag Diam (cm)
29	Maine's Critical Areas Program 1985	Beech Hill			
29	Maine's Critical Areas Program 1985	Cobbosseecontee			
29	Maine's Critical Areas Program 1985	Day Mountain			
29	Maine's Critical Areas Program 1985	Hafey			
29	Maine's Critical Areas Program 1985	Lunksoos			
29	Maine's Critical Areas Program 1985	Mount Philip			
29	Maine's Critical Areas Program 1985	Musquacook			
29	Maine's Critical Areas Program 1985	Pump Handle			
29	Maine's Critical Areas Program 1985	Rockport			
29	Maine's Critical Areas Program 1985	Yankeetuladi			
30	Maine State Planning Office 1986	Little Bigelow			
31	Maissurow 1941	22 stands in Wisconsin, Michigan			
32	Martin 1977	The Bowl--entire watershed			
32	Martin 1977	The Bowl--Area I (West Branch Watershed)			
32	Martin 1977	The Bowl--Area II (West Branch Watershed)			
32	Martin 1977	The Bowl--Area III (East Branch Watershed)			
32	Martin 1977	The Bowl--Area IV (East Branch Watershed)			
33	Martin 1979	The Bowl			
34	McGee in prep (dissertation)	Ampersand Mountain	30	11.4	10[5]
34	McGee in prep (dissertation)	Catlin Lake (Huntington Forest)	60	9.7	10[5]
34	McGee in prep (dissertation)	Gill Brook (Ausable Club)	50	12.5	10[5]
34	McGee in prep (dissertation)	Mason Lake	15	4.4	10[5]
34	McGee in prep (dissertation)	Moose Mountain	20		10[5]
34	McGee in prep (dissertation)	Sucker Brook	25	5.4	10[5]
34	McGee in prep (dissertation)	Whalestail Mountain	25	8.4	10[5]
35	McIntosh 1972	Catskill Mountains--9 stands listed below			
35	McIntosh 1972	Catskill Mountains--Stand 37			
35	McIntosh 1972	Catskill Mountains--Stand 38			
35	McIntosh 1972	Catskill Mountains--Stand 48			
35	McIntosh 1972	Catskill Mountains--Stand 61			
35	McIntosh 1972	Catskill Mountains--Stand 63			
35	McIntosh 1972	Catskill Mountains--Stand 78			
35	McIntosh 1972	Catskill Mountains--Stand 81			
35	McIntosh 1972	Catskill Mountains--Stand 104			
35	McIntosh 1972	Catskill Mountains--Stand 106			
36	Messier and Bellefleur 1988	Duchesnay Experimental Forest			
37	Milfred et al. 1967	Menominee County--Stand #7			

(Table 24 continued on next page)

(*Table 24 continued*)

Map Key	Source/Date	Stand	Standing Dead Trees (Snags) Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Min Snag Diam (cm)
37	Milfred et al. 1967	Menominee County--Stand #19			
38	Mladenoff and Howell 1980	Gogebic Iron Range--sugar maple-dominated			
38	Mladenoff and Howell 1980	Gogebic Iron Range--yellow birch-dominated			
39	Mroz et al. 1985	McCormick Experimental Forest Natural Area			
39	Mroz et al. 1985	Upper Peninsula/Dukes			
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 2			
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 4			
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 5			
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 7			
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 11			
41	Russell 1953	Double Springs			
41	Russell 1953	Unspecified (4 beech gaps)			
42	Selva et al. 1989	Hedgehog Mountain			
42	Selva et al. 1989	Morrison Mountain			
43	Tritton 1980	Charcoal Hearth			
44	Tubbs 1977	Upper Peninsula/Dukes--tract before cutting in 1938			
44	Tubbs 1977	Upper Peninsula/Dukes--virgin tract			
45	Vogelmann et al. 1985	Camel's Hump--1965			
45	Vogelmann et al. 1985	Camel's Hump--1979			
45	Vogelmann et al. 1985	Camel's Hump--1983			
46	Wood 1975	Jefferson Notch			

[1] Not necessarily specific to northern hardwood stands, may apply to other forest types within Big Reed Pond.

[2] Average density of snags is 9.7.

[3] Values apply to Baldwin Hill, Killdare, and McKenzie Mountain combined.

[4] Size limits of snags unspecified, may be 0-7.6 m tall.

[5] Only snags ≥1 m tall were tallied.

Table 25.—*Density, volume, and minimum diameter measured for fallen dead trees (logs) on northern hardwood old-growth study sites.*

Map Key	Source/Date	Stand	Fallen Dead Trees (Logs) Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)
1	Bourdo 1956	Misery Bay			
2	Bratton 1976	Huntington Forest--Site 1			
3	Braun 1950	Unspecified			
3	Braun 1950	Pittsburg Township			
4	Carbonneau 1986a	Charcoal Hearth	354	188	10
4	Carbonneau 1986a	Eagle Cliff	356	185	10
4	Carbonneau 1986a	Mountain Pond		123	10
4	Carbonneau 1986a	The Bowl	481	213	10
4	Carbonneau 1986a	T.V. Williams	227	121	10
5	Carbonneau 1986b	5 stands in New Hampshire			
5	Carbonneau 1986b	T.V. Williams			
6	Cogbill 1985	Big Reed Pond			
7	Crandall 1958	Great Smoky Mountains--1524 m			
7	Crandall 1958	Great Smoky Mountains--1585 m			
7	Crandall 1958	Great Smoky Mountains*--1676 m			
8	Dahir and Lorimer 1996	Little Carp River--Plot 1			
8	Dahir and Lorimer 1996	Little Carp River--Plot 2			
8	Dahir and Lorimer 1996	Little Carp River--Plot 3			
9	Dunwiddie 1993	Cold River A--Plot 1			
9	Dunwiddie 1993	Cold River C--Plot 1			
9	Dunwiddie 1993	Cold River E (Manning)--Plot 2			
9	Dunwiddie 1993	Dunbar Brook--Plot 1			
9	Dunwiddie 1993	Fife Brook--Plot 1			
9	Dunwiddie 1993	Fife Brook--Plot 2			
9	Dunwiddie 1993	Mt. Greylock (Money Brook)--Plot 2			
10	Eyre and Zillgitt 1953	Upper Peninsula--East			
10	Eyre and Zillgitt 1953	Upper Peninsula--West			
10	Eyre and Zillgitt 1953	Upper Peninsula			
11	Fassett 1944	Brule River Basin			
12	Frelich and Lorimer 1991	28 stands in Upper Peninsula			
13	Goodlett 1954	Ayers Hill Quadrangle			
13	Goodlett 1954	Coudersport Quadrangle			
13	Goodlett 1954	Oleona Quadrangle			
14	Hatt et al. 1948	South Fox Island			
14	Hatt et al. 1948	South Manitou Island			
15	Hough and Forbes 1943	East Tionesta Tract			
15	Hough and Forbes 1943	Hearts Content			

(Table 25 continued on next page)

(Table 25 continued)

Map Key	Source/Date	Stand	Fallen Dead Trees (Logs) Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)
16	Hudson et al. 1986	Little Bigelow			
17	Kittredge 1934	Star Island--pine to hardwood transition			
18	Leak 1973	The Bowl			
18	Leak 1973	Bartlett Experimental Forest--Compartment 26			
19	Leak 1974	The Bowl			
20	Leak 1985a	The Bowl			
20	Leak 1985a	Mountain Pond North			
20	Leak 1985a	Mountain Pond South			
20	Leak 1985a	T.V. Williams			
21	Leak 1985b	The Bowl			
22	Leak 1987a	The Bowl			
22	Leak 1987a	Mountain Pond North			
22	Leak 1987a	T.V. Williams			
23	Leak 1987b	Bartlett--fine till - 450 m			
23	Leak 1987b	Bartlett--fine till - 575 m			
23	Leak 1987b	Bartlett--coarse washed till - 425 m			
23	Leak 1987b	Bartlett--coarse washed till - 575 m			
24	Leak and Graber 1974	The Bowl			
24	Leak and Graber 1974	The Bowl			
25	Leopold et al. 1988	Ampersand Mountain 3			
25	Leopold et al. 1988	Baldwin Hill			
25	Leopold et al. 1988	Kildare			
25	Leopold et al. 1988	McKenzie Mountain			
26	Leverett 1991	6 stands in western Massachusetts			
26	Leverett 1991	Cold River			
27	Lutz 1930a	Hearts Content			
28	Maine Critical Areas Program 1983b	Beech Hill			
28	Maine Critical Areas Program 1983b	Big Reed Hardwoods			
28	Maine Critical Areas Program 1983b	Cobbosseecontee			
28	Maine Critical Areas Program 1983b	Hafey Hardwoods			
28	Maine Critical Areas Program 1983b	Haystack Mountain			
28	Maine Critical Areas Program 1983b	Lunksoos Mountain Hardwoods			
28	Maine Critical Areas Program 1983b	Mahoosuc Notch			
28	Maine Critical Areas Program 1983b	Musquacook Hardwoods			
28	Maine Critical Areas Program 1983b	Pump Handle			
28	Maine Critical Areas Program 1983b	Rockport			
28	Maine Critical Areas Program 1983b	Yankeetuladi Hardwoods			

(Table 25 continued on next page)

(Table 25 continued)

			Fallen Dead Trees (Logs)		
Map Key	Source/Date	Stand	Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)
29	Maine's Critical Areas Program 1985	Beech Hill			
29	Maine's Critical Areas Program 1985	Cobbosseecontee			
29	Maine's Critical Areas Program 1985	Day Mountain			
29	Maine's Critical Areas Program 1985	Hafey			
29	Maine's Critical Areas Program 1985	Lunksoos			
29	Maine's Critical Areas Program 1985	Mount Philip			
29	Maine's Critical Areas Program 1985	Musquacook			
29	Maine's Critical Areas Program 1985	Pump Handle			
29	Maine's Critical Areas Program 1985	Rockport			
29	Maine's Critical Areas Program 1985	Yankeetuladi			
30	Maine State Planning Office 1986	Little Bigelow			
31	Maissurow 1941	22 stands in Wisconsin, Michigan			
32	Martin 1977	The Bowl--entire watershed			
32	Martin 1977	The Bowl--Area I (West Branch Watershed)			
32	Martin 1977	The Bowl--Area II (West Branch Watershed)			
32	Martin 1977	The Bowl--Area III (East Branch Watershed)			
32	Martin 1977	The Bowl--Area IV (East Branch Watershed)			
33	Martin 1979	The Bowl			
34	McGee in prep (dissertation)	Ampersand Mountain		105 [1]	10
34	McGee in prep (dissertation)	Catlin Lake (Huntington Forest)		121 [1]	10
34	McGee in prep (dissertation)	Gill Brook (Ausable Club)		120 [1]	10
34	McGee in prep (dissertation)	Mason Lake		122 [1]	10
34	McGee in prep (dissertation)	Moose Mountain		99 [1]	10
34	McGee in prep (dissertation)	Sucker Brook		167 [1]	10
34	McGee in prep (dissertation)	Whalestail Mountain		167 [1]	10
35	McIntosh 1972	Catskill Mountains--9 stands listed below			
35	McIntosh 1972	Catskill Mountains--Stand 37			
35	McIntosh 1972	Catskill Mountains--Stand 38			
35	McIntosh 1972	Catskill Mountains--Stand 48			
35	McIntosh 1972	Catskill Mountains--Stand 61			
35	McIntosh 1972	Catskill Mountains--Stand 63			
35	McIntosh 1972	Catskill Mountains--Stand 78			
35	McIntosh 1972	Catskill Mountains--Stand 81			
35	McIntosh 1972	Catskill Mountains--Stand 104			
35	McIntosh 1972	Catskill Mountains--Stand 106			
36	Messier and Bellefleur 1988	Duchesnay Experimental Forest			
37	Milfred et al. 1967	Menominee County--Stand #7			

(Table 25 continued on next page)

(Table 25 continued)

			Fallen Dead Trees (Logs)		
Map Key	Source/Date	Stand	Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)
37	Milfred et al. 1967	Menominee County--Stand #19			
38	Mladenoff and Howell 1980	Gogebic Iron Range--sugar maple-dominated			
38	Mladenoff and Howell 1980	Gogebic Iron Range--yellow birch-dominated			
39	Mroz et al. 1985	McCormick Experimental Forest Natural Area			
39	Mroz et al. 1985	Upper Peninsula/Dukes			
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 2			
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 4			
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 5			
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 7			
40	Pregitzer and Barnes 1984	McCormick Experimental Forest--Site Unit 11			
41	Russell 1953	Double Springs			
41	Russell 1953	Unspecified (4 beech gaps)			
42	Selva et al. 1989	Hedgehog Mountain			
42	Selva et al. 1989	Morrison Mountain			
43	Tritton 1980	Charcoal Hearth			
44	Tubbs 1977	Upper Peninsula/Dukes--tract before cutting in 1938			
44	Tubbs 1977	Upper Peninsula/Dukes--virgin tract			
45	Vogelmann et al. 1985	Camel's Hump--1965			
45	Vogelmann et al. 1985	Camel's Hump--1979			
45	Vogelmann et al. 1985	Camel's Hump--1983			
46	Wood 1975	Jefferson Notch			

[1] Log volume includes stumps <1 m tall.

Table 26.—*Summary of attributes for old-growth northern hardwood stands (from Tables 17 through 25).*

Attribute	Range	References (Map Key)
Live Tree Density (#/ha)		
- Trees ≥ 2.5 cm d.b.h.	880 - 2280	17, 41
- Trees ≥ 10 cm d.b.h.	190 - 907	4, 9, 10, 12, 18, 28, 34, 35
- Trees ≥ 35 cm d.b.h.	70 - 140	9
- Trees ≥ 50 cm d.b.h.	30 - 85	18, 34, 44
- Trees ≥ 70 cm d.b.h.	5 - 25	18, 34, 37
- Not as specified above		3, 25, 27, 36, 38, 39, 45, 46
Live Tree Basal Area (m^2/ha)		
- Trees ≥ 5 cm d.b.h.	25.3 - 37.6	22, 25
- Trees ≥ 10 cm d.b.h.	25.7 - 73.0	4, 9, 10, 12, 34, 35, 40
- Trees ≥ 35 cm d.b.h.	17.8 - 33.3	9
- Trees ≥ 50 cm d.b.h.	12.7 - 29.6	8, 34
- Trees ≥ 70 cm d.b.h.	2.1 - 11.6	34
- Not as specified above		6, 7, 20, 23, 27, 28, 32, 33, 38, 39, 41, 45
Tree or Stand Age (yr)		
Average Age by Species		
- Sugar Maple	115 - 175	34
- Red Spruce	218	34
- Hemlock	274	34
- Other Species		8, 12, 28, 29, 30
Maximum Age by Species		
- Sugar Maple	100+ - 420	5, 6, 9, 13, 15, 16, 19, 21, 28, 31, 35, 39, 44
- Yellow Birch	101 - 366	5, 10, 15, 16, 19, 24, 28, 31, 34
- Beech	101 - 366	9, 15, 16, 19, 24, 28, 29, 35
- Red Maple	290 - 310	15
- Hemlock	189 - 475	10, 26, 28, 31, 34, 35
- Other Species		17, 29, 36, 37, 43

(Table 26 continued on next page)

(Table 26 continued)

Attribute	Range	References (Map Key)
Maximum Tree Diameter at Breast Height by Species (cm)		
- Sugar Maple	36 - 103	1, 4, 5, 9, 10, 11, 13, 17, 18, 21, 22, 24, 25, 28, 32, 34, 37, 38, 39, 44
- Yellow Birch	4.0 - 112	1, 4, 5, 7, 9, 10, 18, 22, 24, 25, 28, 32, 34, 37, 38, 39, 46
- Basswood	13 - 81	10, 17, 22, 28, 34, 37, 38
- Beech	15 - 74	4, 7, 9, 10, 13, 18, 22, 24, 28, 32, 34, 41
- Elm spp.	47 - 107	10, 37
- Red Maple	10 - 71	4, 9, 17, 18, 22
- Red Oak	36 - 104	17, 28, 37
- Hemlock	32 - 107	1, 9, 10, 18, 22, 28, 34, 37, 38
- Other species		2, 8, 14, 20
Canopy Gaps (%)	10 - 25	28, 42
Standing Dead Trees (Snags)		
Snag Density (#/ha)		
- Snags ≥ 5 cm d.b.h.	70 - 77	25
- Snags ≥ 10 cm d.b.h.	0 - 60	4, 9, 34
- Not as specified above		12, 27
Snag Basal Area (m^2/ha)		
- Snags ≥ 5 cm d.b.h.	0.8 - 7.5	25
- Snags ≥ 10 cm d.b.h.	0 - 12.5	4, 9, 34
- Not as specified above		6
Fallen Dead Trees (Logs)		
Density of Logs (#/ha)		
- Logs ≥ 10 cm d.b.h.	99 - 481	4
Volume of Logs (m^3/ha)		
- Logs ≥ 10 cm d.b.h.	121 - 213	4, 34

DRY AND XERIC OAK FORESTS, WOODLANDS, AND SAVANNAS

COMMUNITY COMPOSITION

Forest Cover Types

The following Society of American Foresters (SAF) forest cover types (Eyre 1980) are included in the dry and xeric oak forests, woodlands, and savannas forest type group:

14 - northern pin oak
40 - post oak-blackjack oak
42 - bur oak
43 - bear oak
44 - chestnut oak
67 - Mohrs ("shin") oak
72 - southern scrub oak
89 - live oak
110 - black oak

The following Combined Data Systems (CDS) forest cover types for the USDA Forest Service Eastern Region (USDA 1974) are included in the dry and xeric oak forests, woodlands, and savannas forest type group:

52 - chestnut oak
57 - scarlet oak
59 - mixed oaks

Species Composition

This forest type group varies greatly, partly because its range is so wide and the number of oak species that can dominate is so great. For ease in discussion, this forest type group can be considered in three subgroups based on dominant species, location, and fire history.

Northern oaks with catastrophic fire.—The oak forests, woodlands, and savannas dominated solely or in various combinations by northern pin oak (*Quercus ellipsoidallis* E.J. Hill), bur oak (*Q. macrocarpa* Michx.), and black oak (*Q. velutina* Lam.) occur in the Upper Great Lakes Region, principally between the southern margin of the Wisconsin glaciation and the northern tension zone of Minnesota, Wisconsin, and Michigan. These oak dominants often have morphological features that encourage fire (*e.g.*, small size, retention of dead leaves and lower branches). Deciduous associates, such as red maple (*Acer rubrum* L.), cherry (*Prunus* L.), sassafras (*Sassafras albidum* [Nutt.] Nees.), and other oaks (*Quercus* L.), are infrequent and usually small. Jack, red, and eastern white pine

▲ *Dry oak forests are found at* ***Stoneface Research Natural Area*** *on the Shawnee National Forest in southern Illinois. Photo 10/93 by Lucy Tyrrell.*

◀ *A large post oak snag stands out in a restored old-growth xeric savanna at **Long Bald**, on Caney Mountain in Missouri. Photo 4/92 by Lucy Tyrrell.*

(*Pinus banksiana* Lamb., *P. resinosa* Ait., and *P. strobus* L., respectively) are common associates; however, pine is much less abundant than oak.

Widespread oaks.—Forests, woodlands, and savannas dominated by white oak (*Quercus alba* L.), black oak (*Q. velutina* Lam.), post oak (*Q. stellata* Wang.), blackjack oak (*Q. marilandica* Muenchh.), chestnut oak (*Q. prinus* L.), and scarlet oak (*Q. coccinea* Muenchh.) occur throughout the central portion of the eastern United States and extend into the Northeast. In the past, reoccurring surface fires maintained open stand conditions.

Southern oaks.—Oaks occurring in the southeastern United States from central Texas and Oklahoma eastward to the Carolinas are primarily small, including turkey oak (*Quercus laevis* Walt.), bluejack oak (*Q. incana* Bartr.), sand post oak (*Q. stellata* var. *margaretta* [Ashe.] Sarg.), Mohr oak (*Q. mohriana* Buckl. ex Rydb.), and sand live oak (*Q. virginiana* var. *geminata* [Small] Sarg.). Larger trees, such as live oak (*Q. virginiana* Mill.), are also present. Fire is also associated with these oaks.

PHYSICAL CONTEXT

Physiographic Provinces

Dry and xeric oak forests, woodlands, and savannas occur in the following physiographic provinces (after Fenneman 1938):

Piedmont
Blue Ridge
Ridge and Valley
Appalachian Plateaus
New England (except Green and White Mountain sections)

Central Lowland
Superior Upland

Ecological Units

Dry and xeric oak forests, woodlands, and savannas occur in several divisions and provinces (see Keys *et al.* 1995):

200	Humid Temperate Domain
210	Warm Continental Division
212	Laurentian Mixed Forest Province
220	Hot Continental Division
221	Eastern Broadleaf Forest (Oceanic) Province
222	Eastern Broadleaf Forest (Continental) Province
250	Prairie Division
251	Prairie Parkland (Temperate) Province
255	Prairie Parkland (Subtropical) Province
M210	Warm Continental Regime Mountains
M212	Adirondack-New England Mixed Forest-Coniferous Forest-Alpine Meadow Province
M220	Hot Continental Regime Mountains
M221	Central Appalachian Broadleaf Forest-Coniferous Forest-Meadow Province

Geographic Distribution

Dry and xeric oak forests, woodlands, and savannas are found throughout most of the eastern United States, from North Dakota south to Texas in the West and across to the Eastern Seaboard from southern Maine to Florida. This forest type group indicates infertile, droughty uplands and has been called "oak barrens." Representative stands also occur on steep, south-facing slopes and along rock outcrops. Although dry conditions may prevail throughout most of the year, soil moisture deficits are most intense in summer. With severe environmental conditions, individual trees may be stunted and gnarled.

Soils

Most stands are located on coarse-textured soils, or where bedrock is near the surface and soil moisture is limiting. Soils are typically Inceptisols, Entisols, or Spodosols.

DISTURBANCE

In presettlement times, the open condition of the woodlands and savannas was maintained by poor site conditions, fire, or both. Frequent fire allowed shade-intolerant grasses, forbs, and shrubs to dominate the understory. During severe droughts, large fires burned through the stands. Today, due to fire suppression, many former oak woodlands and savannas have been replaced by closed-canopy oak forests, especially on sites where presettlement fire limited stand density. Hence, most present-day woodlands and savannas are found on sites where stand density is limited by soil moisture.

▶ *Chestnut oak is growing on a dry gravel slope in the area known as* ***Land-Between-the-Lakes*** *in northern Kentucky. The oldest trees in this area are 150 years old. Photo 4/92 by Lucy Tyrrell.*

RELATION TO OTHER FOREST TYPES

The geographic distribution and dominant species of widespread oaks overlap those of dry-mesic oak forests.

STRUCTURAL CHARACTERISTICS OF OLD-GROWTH STANDS

Information about dry and xeric forests, woodlands, and savannas in an old-growth condition is included in Figure 6 and Tables 27 through 36.

SELECTED REPRESENTATIVE OLD-GROWTH STANDS

Arkansas

Hot Springs National Park

Connecticut

Stonington
(Braun 1950)

Indiana

Indiana Dunes

Lilly-Dickey Woods, Brown Co.
(Lindsey *et al.* 1969)

Minnesota

Allison Savanna

Boundary Waters Canoe Area Wilderness, Superior National Forest

Missouri

Cedar Creek Natural History Area, Jackson Co.

Ashland Wildlife Area, Boone Co.
(Pallardy *et al.* 1991)

Burr Oak Woods Natural Area, Jackson Co.

Mark Twain National Forest, Taney Co.
(Kucera and Martin 1957)

Mudlick Mountain Natural Area, Sam A. Baker State Park

North Carolina

Great Smoky Mountains National Park

Linville Gorge, Pisgah National Forest

Ohio

Hawk Woods, Athens Co.
(McCarthy *et al.* 1987)

Oklahoma

[selected areas in] W. Oklahoma (prairie-forest ecotone)
(Rice and Penfound 1959)

South Carolina

Post Oak Stand, Edgefield Ranger District

Tennessee

Great Smoky Mountain National Park

Texas

Hickory Creek Savanna Unit, Big Thicket National Preserve, Tyler Co.
(Streng and Harcombe, 1982)

Wisconsin

[various sites in] Southeastern Wisconsin
(Bray 1960)

FOR ADDITIONAL INFORMATION

Additional references that pertain to dry and xeric oak forests, woodlands, and savannas but are not cited in tables or text are listed by forest type group in Appendix C.

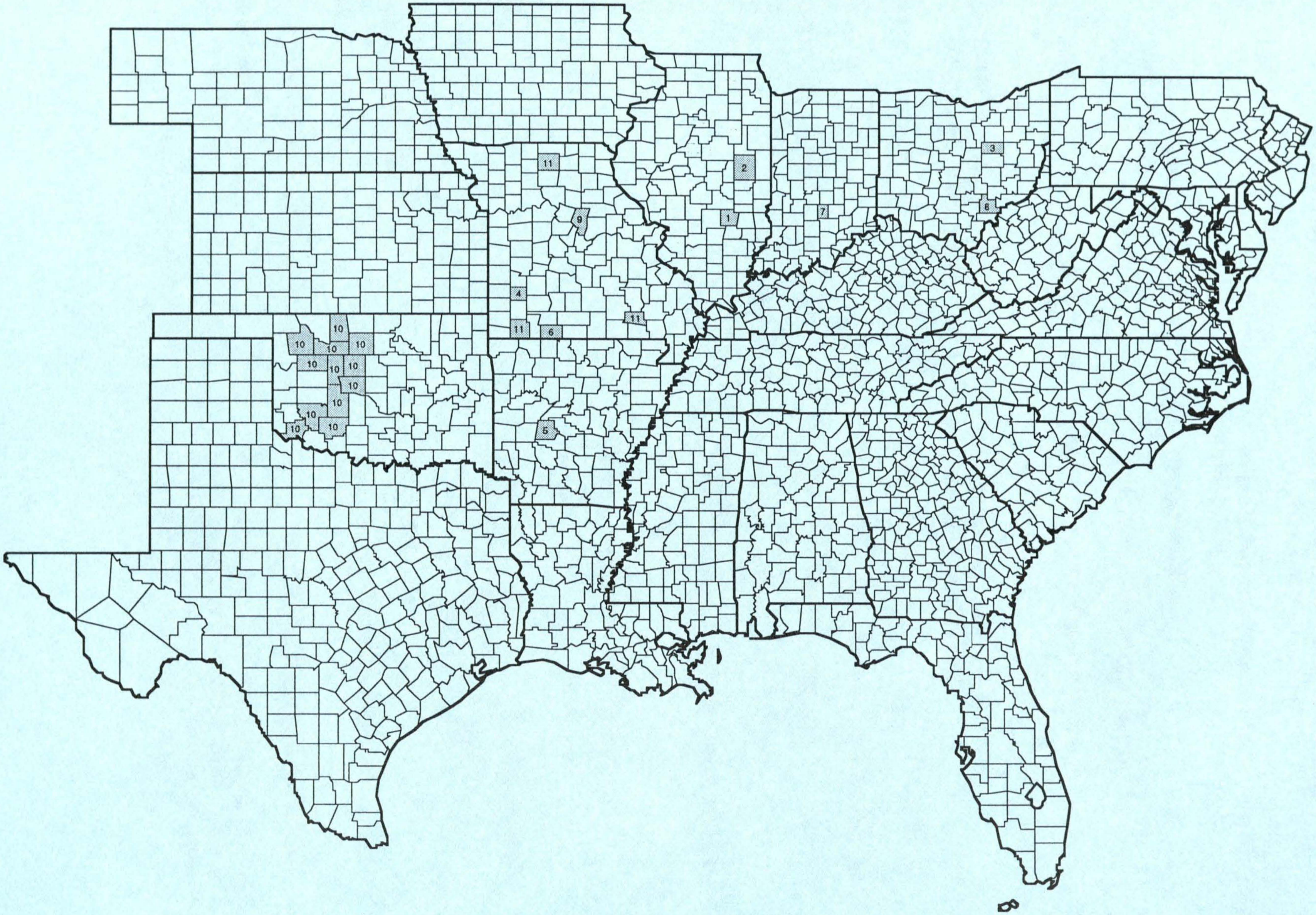
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Figure 6.—*General location of studies that provide some stand structure information about old-growth dry and xeric oak forests, woodlands, and savannas. Shaded counties contain at least one study. Numbers correspond to the cited references listed under Map Key below and in Tables 27 through 36. States are indicated using two-letter postal abbreviations.*

Map Key	Source/Date	State or Province	County	Map Key	Source/Date	State or Province	County
1	Coates et al. 1992	IL	Effingham	8	McCarthy et al. 1987	OH	Athens
2	Gleason 1912	IL	Champaign	9	Pallardy et al. 1991	MO	Boone
3	Gordon 1969	OH	Holmes	10	Rice and Penfound 1959	OK	Alfalfa, Blaine, Caddo, Canadian, Comanche, Dewey, Garfield, Jackson, Kingfisher, Kiowa, Major, Woodward
4	Howell and Kucera 1956	MO	Dade				
5	Johnson and Schnell 1985	AR	Garland				
6	Kucera and Martin 1957	MO	Taney	11	Spetich et al. 1996	MO	Barry, Carter, Sullivan
7	Lindsey et al. 1969	IN	Brown				

Table 27.—*Location, size, and elevation of dry and xeric oak old-growth study sites.*

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
1	Coates et al. 1992	Lake Sara	IL	Effingham	3	unspecified
2	Gleason 1912	Bur Oak Grove	IL	Champaign	770	unspecified
3	Gordon 1969	Killbuck Township	OH	Holmes	unspecified	unspecified
4	Howell and Kucera 1956	Dade County presettlement forest	MO	Dade	unspecified	unspecified
5	Johnson and Schnell 1985	Hot Springs National Park--Site 7	AR	Garland	unspecified	150-430
6	Kucera and Martin 1957	5 sites in Mark Twain National Forest	MO	Taney	unspecified	unspecified
7	Lindsey et al. 1969	Lilly-Dickey Woods	IN	Brown	154	unspecified
8	McCarthy et al. 1987	Hawk Woods	OH	Athens	35	230-300
9	Pallardy et al. 1991	Ashland Wildlife Area--Dry Ridge/Slope 1968	MO	Boone	890	unspecified
9	Pallardy et al. 1991	Ashland Wildlife Area--Dry Ridge/Slope 1982	MO	Boone	890	unspecified
10	Rice and Penfound 1959	West Oklahoma--Alfalfa County	OK	Alfalfa	unspecified	unspecified
10	Rice and Penfound 1959	West Oklahoma--Blaine County	OK	Blaine	unspecified	unspecified
10	Rice and Penfound 1959	West Oklahoma--Caddo County	OK	Caddo	unspecified	unspecified
10	Rice and Penfound 1959	West Oklahoma--Canadian County	OK	Canadian	unspecified	unspecified
10	Rice and Penfound 1959	West Oklahoma--Comanche County	OK	Comanche	unspecified	unspecified
10	Rice and Penfound 1959	West Oklahoma--Dewey County	OK	Dewey	unspecified	unspecified
10	Rice and Penfound 1959	West Oklahoma--Garfield County	OK	Garfield	unspecified	unspecified
10	Rice and Penfound 1959	West Oklahoma--Jackson County	OK	Jackson	unspecified	unspecified
10	Rice and Penfound 1959	West Oklahoma--Kingfisher County	OK	Kingfisher	unspecified	unspecified
10	Rice and Penfound 1959	West Oklahoma--Kiowa County	OK	Kiowa	unspecified	unspecified
10	Rice and Penfound 1959	West Oklahoma--Major County	OK	Major	unspecified	unspecified
10	Rice and Penfound 1959	West Oklahoma--Woodward County	OK	Woodward	unspecified	unspecified
11	Spetich et al. 1996	Big Spring	MO	Carter	unspecified	unspecified
11	Spetich et al. 1996	Dark Hollow	MO	Sullivan	unspecified	unspecified
11	Spetich et al. 1996	Roaring River	MO	Barry	unspecified	unspecified

Table 28.—*Criteria used by sources to identify old-growth stands, and information about stand composition of dry and xeric oak old-growth study sites.*

Map Key	Source/Date	Stand	Criteria for Stand Selection and Stand Composition
1	Coates et al. 1992	Lake Sara	Well-maintained, understory burning [1]; post oak (49%)-black oak (32%) [2]
2	Gleason 1912	Bur Oak Grove	Isolated area of forest; fire cessation since mid-1800's; bur oak [3]
3	Gordon 1969	Killbuck Township	Left undisturbed; mixed oak-oak savannah [4]
4	Howell and Kucera 1956	Dade County presettlement forest	Original forest-prairie transition; post oak (33%)-blackjack oak (18%)
5	Johnson and Schnell 1985	Hot Springs National Park--Site 7	Old growth; fire in 1980; black oak-white oak-hickory-pine
6	Kucera and Martin 1957	5 sites in Mark Twain National Forest	Remnant xerophytic oaks on chert knolls and ridges; post oak (53%) [5]
7	Lindsey et al. 1969	Lilly-Dickey Woods	No cutting since 1900 [6]; chestnut oak (52%)-black oak (16%)
8	McCarthy et al. 1987	Hawk Woods	Old-growth forest; minimally disturbed; chestnut oak (59%)
9	Pallardy et al. 1991	Ashland Wildlife Area--Dry Ridge/Slope 1968	Reserve; second-growth oak-hickory [7]
9	Pallardy et al. 1991	Ashland Wildlife Area--Dry Ridge/Slope 1982	Reserve; second-growth oak-hickory [7]
10	Rice and Penfound 1959	West Oklahoma--Alfalfa County	Upland, relatively undisturbed; blackjack oak (99%)
10	Rice and Penfound 1959	West Oklahoma--Blaine County	Upland, relatively undisturbed; blackjack oak (65%)-post oak (34%)
10	Rice and Penfound 1959	West Oklahoma--Caddo County	Upland, relatively undisturbed; blackjack oak (77%)-post oak (22%)
10	Rice and Penfound 1959	West Oklahoma--Canadian County	Upland, relatively undisturbed; blackjack oak (83%)-post oak (7%)
10	Rice and Penfound 1959	West Oklahoma--Comanche County	Upland, relatively undisturbed; post oak (56%)-blackjack oak (21%)
10	Rice and Penfound 1959	West Oklahoma--Dewey County	Upland, relatively undisturbed; blackjack oak (81%)-post oak (14%)
10	Rice and Penfound 1959	West Oklahoma--Garfield County	Upland, relatively undisturbed; blackjack oak (98%)
10	Rice and Penfound 1959	West Oklahoma--Jackson County	Upland, relatively undisturbed; post oak (63%)-blackjack oak (30%)
10	Rice and Penfound 1959	West Oklahoma--Kingfisher County	Upland, relatively undisturbed; blackjack oak (94%)-post oak (6%)
10	Rice and Penfound 1959	West Oklahoma--Kiowa County	Upland, relatively undisturbed; post oak (85%)
10	Rice and Penfound 1959	West Oklahoma--Major County	Upland, relatively undisturbed; blackjack oak (95%)-post oak (2%)
10	Rice and Penfound 1959	West Oklahoma--Woodward County	Upland, relatively undisturbed; post oak (32%)-blackjack oak (28%)
11	Spetich et al. 1996	Big Spring	Minimal human-caused disturbance [8]; trees > 150 yr; black oak
11	Spetich et al. 1996	Dark Hollow	Minimal human-caused disturbance [8]; trees > 150 yr; white oak-red oak
11	Spetich et al. 1996	Roaring River	Minimal human-caused disturbance [8]; trees > 150 yr; black oak

[1] Understory has been burned for last 10 yr to keep woods open.

[2] Composition based on basal area.

[3] Large bur oaks in mid-grove.

[4] Primarily red oak-white oak-black oak-red maple-shagbark hickory.

[5] Post oak-black oak-white oak-black jack oak; separated by narrow ecotone from prairie glade.

[6] Cleared for agriculture circa 1900, chiefly for pasture.

[7] High white oak basal area; little oak regeneration except on xeric and recently disturbed sites; shift to mesic species, e.g., sugar maple.

[8] Stands experienced minimal disturbance during the past 80-100 yr, and had multi-layered canopies.

Table 29.—*Methods used to study old-growth dry and xeric oaks (condensed from the cited references).*

Map Key	Source/Date	Stand	Possible Confusion With These Forest Types [1]	Sampling Methods
1	Coates et al. 1992	Lake Sara		48 25 m x 25 m quadrats
2	Gleason 1912	Bur Oak Grove	MOak [2]	Observations
3	Gordon 1969	Killbuck Township		Unspecified
4	Howell and Kucera 1956	Dade County presettlement forest	D-MOak	6500 witness trees from original land survey notes
5	Johnson and Schnell 1985	Hot Springs National Park--Site 7		Fuel sampling in 20 10-m diameter circular plots
6	Kucera and Martin 1957	5 sites in Mark Twain National Forest		40 random pairs at each site (400 trees sampled)
7	Lindsey et al. 1969	Lilly-Dickey Woods	D-MOak	Full tally of 1.8 ha of upper slopes and ridges
8	McCarthy et al. 1987	Hawk Woods	MOak, D-MOak	14 100-m^2 circular plots along elevation contour
9	Pallardy et al. 1991	Ashland Wildlife Area--Dry Ridge/Slope 1968	MOak	61 0.08-ha nested circular plots
9	Pallardy et al. 1991	Ashland Wildlife Area--Dry Ridge/Slope 1982	MOak	61 0.08-ha nested circular plots
10	Rice and Penfound 1959	West Oklahoma--Alfalfa County		Augmented variable radius plots; 3 stands per county
10	Rice and Penfound 1959	West Oklahoma--Blaine County		Augmented variable radius plots; 3 stands per county
10	Rice and Penfound 1959	West Oklahoma--Caddo County		Augmented variable radius plots; 3 stands per county
10	Rice and Penfound 1959	West Oklahoma--Canadian County		Augmented variable radius plots; 3 stands per county
10	Rice and Penfound 1959	West Oklahoma--Comanche County		Augmented variable radius plots; 3 stands per county
10	Rice and Penfound 1959	West Oklahoma--Dewey County		Augmented variable radius plots; 3 stands per county
10	Rice and Penfound 1959	West Oklahoma--Garfield County		Augmented variable radius plots; 3 stands per county
10	Rice and Penfound 1959	West Oklahoma--Jackson County		Augmented variable radius plots; 3 stands per county
10	Rice and Penfound 1959	West Oklahoma--Kingfisher County		Augmented variable radius plots; 3 stands per county
10	Rice and Penfound 1959	West Oklahoma--Kiowa County		Augmented variable radius plots; 3 stands per county
10	Rice and Penfound 1959	West Oklahoma--Major County		Augmented variable radius plots; 3 stands per county
10	Rice and Penfound 1959	West Oklahoma--Woodward County		Augmented variable radius plots; 3 stands per county
11	Spetich et al. 1996	Big Spring		30 0.1-ha plots located along a grid
11	Spetich et al. 1996	Dark Hollow		30 0.1-ha plots located along a grid
11	Spetich et al. 1996	Roaring River		30 0.1-ha plots located along a grid

[1] MOak = mesic oak, D-MOak = dry-mesic oak.

[2] Composition variable within stand (oak-hickory at south; bur oak at middle; red oak at north).

Table 30.—*Density of live trees ≥10, ≥50, and ≥70 cm for dry and xeric oak old-growth study sties. For other minimum sizes, the density is listed under "≥X cm", with the minimum size for tallying trees given as "Min Diam X (cm)".*

			Live Tree Density				
Map Key	**Source/Date**	**Stand**	**≥10 cm (#/ha)**	**≥50 cm (#/ha)**	**≥70 cm (#/ha)**	**≥X cm (#/ha)**	**Min Diam X (cm)**
1	Coates et al. 1992	Lake Sara	280			36	40
2	Gleason 1912	Bur Oak Grove					
3	Gordon 1969	Killbuck Township					
4	Howell and Kucera 1956	Dade County presettlement forest				[1]	unspecified
5	Johnson and Schnell 1985	Hot Springs National Park--Site 7					
6	Kucera and Martin 1957	5 sites in Mark Twain National Forest	304			1850	2.5
7	Lindsey et al. 1969	Lilly-Dickey Woods	384				
8	McCarthy et al. 1987	Hawk Woods	443				
9	Pallardy et al. 1991	Ashland Wildlife Area--Dry Ridge/Slope 1968				560	unspecified
9	Pallardy et al. 1991	Ashland Wildlife Area--Dry Ridge/Slope 1982				452	unspecified
10	Rice and Penfound 1959	West Oklahoma--Alfalfa County				}410 [2]	unspecified
10	Rice and Penfound 1959	West Oklahoma--Blaine County				}	unspecified
10	Rice and Penfound 1959	West Oklahoma--Caddo County				}	unspecified
10	Rice and Penfound 1959	West Oklahoma--Canadian County				}	unspecified
10	Rice and Penfound 1959	West Oklahoma--Comanche County				}	unspecified
10	Rice and Penfound 1959	West Oklahoma--Dewey County				}	unspecified
10	Rice and Penfound 1959	West Oklahoma--Garfield County				}	unspecified
10	Rice and Penfound 1959	West Oklahoma--Jackson County				}	unspecified
10	Rice and Penfound 1959	West Oklahoma--Kingfisher County				}	unspecified
10	Rice and Penfound 1959	West Oklahoma--Kiowa County				}	unspecified
10	Rice and Penfound 1959	West Oklahoma--Major County				}	unspecified
10	Rice and Penfound 1959	West Oklahoma--Woodward County				}	unspecified
11	Spetich et al. 1996	Big Spring				1900	2
11	Spetich et al. 1996	Dark Hollow				5567	2
11	Spetich et al. 1996	Roaring River				3633	2

[1] Some estimate of density can be obtained from the average distance to witness trees (18.8 m).

[2] Density is average of data from 36 dry upland-xeric upland stands in western Oklahoma at prairie-forest ecotone.

Table 31.—*Basal area of live trees ≥10, ≥50, and ≥70 cm for dry and xeric oak old-growth study sites. For other minimum sizes, the basal area is listed under "≥X cm", with the minimum size for tallying trees given as "Min Diam X (cm)".*

Map Key	Source/Date	Stand	Live Tree Basal Area (BA) ≥10 cm (m^2/ha)	≥50 cm (m^2/ha)	≥70 cm (m^2/ha)	≥X cm (m^2/ha)	Min Diam X (cm)
1	Coates et al. 1992	Lake Sara	19.5				
2	Gleason 1912	Bur Oak Grove					
3	Gordon 1969	Killbuck Township					
4	Howell and Kucera 1956	Dade County presettlement forest					
5	Johnson and Schnell 1985	Hot Springs National Park--Site 7					
6	Kucera and Martin 1957	5 sites in Mark Twain National Forest	9.1			11.1	2.5
7	Lindsey et al. 1969	Lilly-Dickey Woods	28.1 [1]				
8	McCarthy et al. 1987	Hawk Woods	21.7				
9	Pallardy et al. 1991	Ashland Wildlife Area--Dry Ridge/Slope 1968				21.5	unspecified
9	Pallardy et al. 1991	Ashland Wildlife Area--Dry Ridge/Slope 1982				21.8	unspecified
10	Rice and Penfound 1959	West Oklahoma--Alfalfa County				9.4	unspecified
10	Rice and Penfound 1959	West Oklahoma--Blaine County				6.4	unspecified
10	Rice and Penfound 1959	West Oklahoma--Caddo County				8.7	unspecified
10	Rice and Penfound 1959	West Oklahoma--Canadian County				5.5	unspecified
10	Rice and Penfound 1959	West Oklahoma--Comanche County				13.0	unspecified
10	Rice and Penfound 1959	West Oklahoma--Dewey County				5.3	unspecified
10	Rice and Penfound 1959	West Oklahoma--Garfield County				10.5	unspecified
10	Rice and Penfound 1959	West Oklahoma--Jackson County				8.1	unspecified
10	Rice and Penfound 1959	West Oklahoma--Kingfisher County				7.7	unspecified
10	Rice and Penfound 1959	West Oklahoma--Kiowa County				6.0	unspecified
10	Rice and Penfound 1959	West Oklahoma--Major County				9.2	unspecified
10	Rice and Penfound 1959	West Oklahoma--Woodward County				2.3	unspecified
11	Spetich et al. 1996	Big Spring				24.1	2
11	Spetich et al. 1996	Dark Hollow				24.9	2
11	Spetich et al. 1996	Roaring River				24.8	2

[1] Reported basal area is 122.4 per acre; conversion to m^2/ha assumed the units were in square feet and not in square inches.

Table 32.—*Average and maximum tree age by species for dry and xeric oak old-growth study sites.*

Map Key	Source/Date	Stand	Average Age (yr) Oak spp.	Maximum Tree Age (yr) Post Oak	Blackjack Oak	Black Oak	Chestnut Oak	Oak spp.
1	Coates et al. 1992	Lake Sara						
2	Gleason 1912	Bur Oak Grove						
3	Gordon 1969	Killbuck Township						
4	Howell and Kucera 1956	Dade County presettlement forest						
5	Johnson and Schnell 1985	Hot Springs National Park--Site 7						
6	Kucera and Martin 1957	5 sites in Mark Twain National Forest						
7	Lindsey et al. 1969	Lilly-Dickey Woods						
8	McCarthy et al. 1987	Hawk Woods						
9	Pallardy et al. 1991	Ashland Wildlife Area--Dry Ridge/Slope 1968						
9	Pallardy et al. 1991	Ashland Wildlife Area--Dry Ridge/Slope 1982	65 - 150					150
10	Rice and Penfound 1959	West Oklahoma--Alfalfa County						
10	Rice and Penfound 1959	West Oklahoma--Blaine County						
10	Rice and Penfound 1959	West Oklahoma--Caddo County						
10	Rice and Penfound 1959	West Oklahoma--Canadian County						
10	Rice and Penfound 1959	West Oklahoma--Comanche County						
10	Rice and Penfound 1959	West Oklahoma--Dewey County						
10	Rice and Penfound 1959	West Oklahoma--Garfield County						
10	Rice and Penfound 1959	West Oklahoma--Jackson County						
10	Rice and Penfound 1959	West Oklahoma--Kingfisher County						
10	Rice and Penfound 1959	West Oklahoma--Kiowa County						
10	Rice and Penfound 1959	West Oklahoma--Major County						
10	Rice and Penfound 1959	West Oklahoma--Woodward County						
11	Spetich et al. 1996	Big Spring	112+					
11	Spetich et al. 1996	Dark Hollow	130+					
11	Spetich et al. 1996	Roaring River						

Table 33.—*Maximum tree diameter by species, and the percentage of the tree canopy that is in gaps for dry and xeric oak old-growth study sites.*

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm) Black Oak	Post Oak	White Oak	Bur Oak	Chestnut Oak	Oak spp.	Canopy Gaps (%)
1	Coates et al. 1992	Lake Sara	40+	40+					
2	Gleason 1912	Bur Oak Grove				91 - 122		61 [1]	
3	Gordon 1969	Killbuck Township	102 [2]		91 [2]				
4	Howell and Kucera 1956	Dade County presettlement forest							
5	Johnson and Schnell 1985	Hot Springs National Park--Site 7							
6	Kucera and Martin 1957	5 sites in Mark Twain National Forest		25+					
7	Lindsey et al. 1969	Lilly-Dickey Woods					67		
8	McCarthy et al. 1987	Hawk Woods							
9	Pallardy et al. 1991	Ashland Wildlife Area--Dry Ridge/Slope 1968							
9	Pallardy et al. 1991	Ashland Wildlife Area--Dry Ridge/Slope 1982							
10	Rice and Penfound 1959	West Oklahoma--Alfalfa County							
10	Rice and Penfound 1959	West Oklahoma--Blaine County							
10	Rice and Penfound 1959	West Oklahoma--Caddo County							
10	Rice and Penfound 1959	West Oklahoma--Canadian County							
10	Rice and Penfound 1959	West Oklahoma--Comanche County							
10	Rice and Penfound 1959	West Oklahoma--Dewey County							
10	Rice and Penfound 1959	West Oklahoma--Garfield County							
10	Rice and Penfound 1959	West Oklahoma--Jackson County							
10	Rice and Penfound 1959	West Oklahoma--Kingfisher County							
10	Rice and Penfound 1959	West Oklahoma--Kiowa County							
10	Rice and Penfound 1959	West Oklahoma--Major County							
10	Rice and Penfound 1959	West Oklahoma--Woodward County							
11	Spetich et al. 1996	Big Spring	69						
11	Spetich et al. 1996	Dark Hollow						89	
11	Spetich et al. 1996	Roaring River	78						

[1] Shingle oak.

[2] Ages obtained from trees removed from ravine in 1965.

Table 34.—*Density, basal area, and minimum diameter measured for standing dead trees (snags) on dry and xeric oak old-growth study sites.*

Map Key	Source/Date	Stand	Standing Dead Trees (Snags) Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Min Snag Diam (cm)
1	Coates et al. 1992	Lake Sara			
2	Gleason 1912	Bur Oak Grove			
3	Gordon 1969	Killbuck Township			
4	Howell and Kucera 1956	Dade County presettlement forest			
5	Johnson and Schnell 1985	Hot Springs National Park--Site 7	[1]		unspecified
6	Kucera and Martin 1957	5 sites in Mark Twain National Forest			
7	Lindsey et al. 1969	Lilly-Dickey Woods			
8	McCarthy et al. 1987	Hawk Woods			
9	Pallardy et al. 1991	Ashland Wildlife Area--Dry Ridge/Slope 1968			
9	Pallardy et al. 1991	Ashland Wildlife Area--Dry Ridge/Slope 1982			
10	Rice and Penfound 1959	West Oklahoma--Alfalfa County			
10	Rice and Penfound 1959	West Oklahoma--Blaine County			
10	Rice and Penfound 1959	West Oklahoma--Caddo County			
10	Rice and Penfound 1959	West Oklahoma--Canadian County			
10	Rice and Penfound 1959	West Oklahoma--Comanche County		[2]	unspecified
10	Rice and Penfound 1959	West Oklahoma--Dewey County			
10	Rice and Penfound 1959	West Oklahoma--Garfield County		[3]	
10	Rice and Penfound 1959	West Oklahoma--Jackson County			
10	Rice and Penfound 1959	West Oklahoma--Kingfisher County		[4]	
10	Rice and Penfound 1959	West Oklahoma--Kiowa County		[5]	unspecified
10	Rice and Penfound 1959	West Oklahoma--Major County		[6]	unspecified
10	Rice and Penfound 1959	West Oklahoma--Woodward County		[7]	unspecified
11	Spetich et al. 1996	Big Spring	189		2
11	Spetich et al. 1996	Dark Hollow	139		2
11	Spetich et al. 1996	Roaring River	207		2

[1] Biomass of snags is 25,100 kg/ha.

[2] Average mortality from drought in 1956-7 is 10.8%.

[3] Average mortality from drought in 1956-7 is 15.3%.

[4] Average mortality from drought in 1956-7 is 6.2%.

[5] Average mortality from drought in 1956-7 is 10.0%.

[6] Average mortality from drought in 1956-7 is 14.8%.

[7] Average mortality from drought in 1956-7 is 42.3%.

Table 35.—*Density, volume, and minimum diameter measured for fallen dead trees (logs) on dry and xeric oak old-growth study sites.*

Map Key	Source/Date	Stand	Fallen Dead Trees (Logs) Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)
1	Coates et al. 1992	Lake Sara			
2	Gleason 1912	Bur Oak Grove			
3	Gordon 1969	Killbuck Township			
4	Howell and Kucera 1956	Dade County presettlement forest			
5	Johnson and Schnell 1985	Hot Springs National Park--Site 7	[1]		7.5
6	Kucera and Martin 1957	5 sites in Mark Twain National Forest			
7	Lindsey et al. 1969	Lilly-Dickey Woods			
8	McCarthy et al. 1987	Hawk Woods			
9	Pallardy et al. 1991	Ashland Wildlife Area--Dry Ridge/Slope 1968			
9	Pallardy et al. 1991	Ashland Wildlife Area--Dry Ridge/Slope 1982			
10	Rice and Penfound 1959	West Oklahoma--Alfalfa County			
10	Rice and Penfound 1959	West Oklahoma--Blaine County			
10	Rice and Penfound 1959	West Oklahoma--Caddo County			
10	Rice and Penfound 1959	West Oklahoma--Canadian County			
10	Rice and Penfound 1959	West Oklahoma--Comanche County			
10	Rice and Penfound 1959	West Oklahoma--Dewey County			
10	Rice and Penfound 1959	West Oklahoma--Garfield County			
10	Rice and Penfound 1959	West Oklahoma--Jackson County			
10	Rice and Penfound 1959	West Oklahoma--Kingfisher County			
10	Rice and Penfound 1959	West Oklahoma--Kiowa County			
10	Rice and Penfound 1959	West Oklahoma--Major County			
10	Rice and Penfound 1959	West Oklahoma--Woodward County			
11	Spetich et al. 1996	Big Spring		32.0	10
11	Spetich et al. 1996	Dark Hollow		24.3	10
11	Spetich et al. 1996	Roaring River		34.6	10

[1] Biomass of logs is 10,500 kg/ha.

Table 36.—*Summary of attributes for old-growth dry and xeric oak stands (from Tables 27 through 35).*

Attribute	Range	References (Map Key)
Live Tree Density (#/ha)		
- Trees ≥ 2 cm d.b.h.	1900 - 5567	11
- Trees ≥ 10 cm d.b.h.	280 - 443	1, 6, 7, 9
- Trees ≥ 40 cm d.b.h.	36	1
- Trees ≥ 50 cm d.b.h.	--	--
- Trees ≥ 70 cm d.b.h.	--	--
- Not as specified above		4, 9, 10
Live Tree Basal Area (m^2/ha)		
- Trees ≥ 2 cm d.b.h.	24.1 - 24.9	11
- Trees ≥ 2.5 cm d.b.h.	11.1	6
- Trees ≥ 10 cm d.b.h.	9.1 - 28.1	1, 6, 7, 8
- Trees ≥ 50 cm d.b.h.	--	--
- Trees ≥ 70 cm d.b.h.	--	--
- Not as specified above		9, 10
Tree or Stand Age (yr)		
Average Age by Species		
- Oak spp.	65 - 150	9, 11
Maximum Age by Species		
- Oak spp.	150	9
Maximum Tree Diameter at Breast Height by Species (cm)		
- Black Oak	40+ - 102	1, 3, 11
- Pin Oak	25+ - 40+	1, 6
- White Oak	91	3
- Bur Oak	91 - 122	2
- Chestnut Oak	67	7
- Oak	61 - 88.5	2, 11

(Table 36 continued on next page)

(Table 36 continued)

Attribute	Range	References (Map Key)
Canopy Gaps (%)	--	--
Standing Dead Trees (Snags)		
Snag Density (#/ha)		
- Snags ≥ 2 cm d.b.h.	139 - 207	11
- Not as specified above		
Snag Basal Area (m^2/ha)		
- Snags ≥ 10 cm d.b.h.		5, 10
Fallen Dead Trees (Logs)		
Density of Logs (#/ha)		
- Logs ≥ 7.5 cm d.b.h.	--	--
Volume of Logs (m^3/ha)		
- Logs ≥ 10 cm d.b.h.	24.3 - 34.6	11

MESIC AND WET-MESIC NORTHERN OAK FORESTS, WOODLANDS, AND SAVANNAS

COMMUNITY COMPOSITION

Forest Cover Types

The following Society of American Foresters (SAF) forest cover types (Eyre 1980) are included in the mesic and wet-mesic northern oak forests, woodlands, and savannas forest type group:

42 - bur oak
52 - white oak-black oak-northern red oak
53 - white oak
55 - northern red oak
110 - black oak

The following Combined Data Systems (CDS) forest cover types for the USDA Forest Service Eastern Region (USDA 1974) are included in the mesic and wet-mesic northern oak forests, woodlands, and savannas forest type group:

53 - black oak/scarlet oak/hickory
54 - white oak
55 - northern red oak
59 - mixed oaks
89 - mixed hardwoods

Species Composition

Mesic and wet-mesic oak forests are usually comprised of various mixtures of overstory northern red oak (*Quercus rubra* L.), white oak (*Q. alba* L.), black oak (*Q. velutina* Lam.), and hickories (*Carya* Nutt.). These species also occur in woodlands and savannas; however, bur oak (*Q. macrocarpa* Michx.) is usually more prevalent in these open situations.

▲ ***Donaldson's Woods*** *in Indiana, like many mesic oak forests in the Central Hardwoods Region, are succeeding to mixed or western mesophytic forests in the absence of fire. Donaldson's Woods contain white oak, red oak, and shagbark hickory, with increasing sugar maple in the understory. See Lindsey* et al. *(1969). Photo 4/92 by Lucy Tyrrell.*

PHYSICAL CONTEXT

Physiographic Provinces

The mesic and wet-mesic northern oak forests, woodlands, and savannas occur in the following physiographic provinces (after Fenneman 1938):

Piedmont	(all sections)
Ridge and Valley	(Hudson-Champlain and Middle sections)
Appalachian Plateaus	(Allegheny Mountain, Unglaciated and Glaciated Allegheny Plateaus, Catskill Mountains, and Mohawk sections)
New England	(Upland and Seaboard Lowland section)
Central Lowland	(all sections except Osage)
Superior Upland	

Ecological Units

Mesic and wet-mesic northern oak forests, woodlands, and savannas occur in several divisions and provinces (see Keys *et al.* 1995):

200	Humid Temperate Domain
220	Hot Continental Division
221	Eastern Broadleaf Forest (Oceanic) Province
222	Eastern Broadleaf Forest (Continental) Province
250	Prairie Division
251	Prairie Parkland (Temperate) Province
M220	Hot Continental Regime Mountains
M221	Central Appalachian Broadleaf Forest-Coniferous Forest-Meadow Province

Geographic Distribution

The range of mesic and wet-mesic northern oak forests, woodlands, and savannas extends from about the 38th parallel northward to the Canadian border. In the Upper Great Lakes (Minnesota, Upper Peninsula of Michigan) and the New England States from northeastern New York through Maine, the mesic northern oaks merge into northern hardwoods. The southern boundary of mesic northern oaks generally follows the edge of the Wisconsin Drift. In the Appalachians, these stands are restricted to low elevations and often occur in broad valleys and surrounding mountain toe slopes. In the northern portion of its range, this forest type group usually occurs on warm sites that face south and west. The best examples of this forest type group occur in and along the edge of the Prairie Peninsula, which extends eastward from central Illinois to western Pennsylvania (Transeau 1935).

Soils

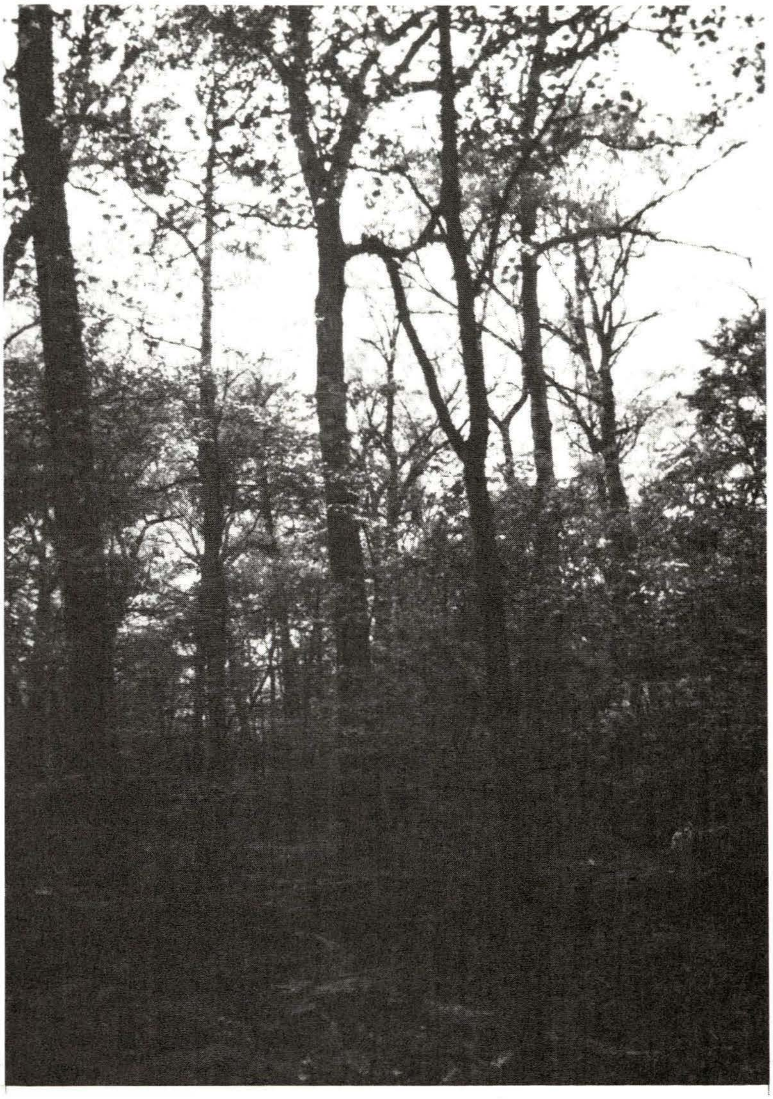
Mesic oak forests, woodlands, and savannas are most common on fine-textured soils; however, they will also occur on coarse-textured soils that are moist due to landscape position or underlying hardpans.

DISTURBANCE

In presettlement times, these oak forests, woodlands, and savannas burned frequently. Well adapted to fire (thick bark, ability to reproduce vegetatively, etc.), oaks on these sites had an advantage over species that were competitively superior but less tolerant of fire, such as sugar maple (*Acer saccharum* Marsh.) and American beech (*Fagus grandifolia* Ehrh.).

Oak density over the presettlement landscape was dictated by fire intensity and frequency, ranging from low densities in open savannas that burned hot and frequently to higher densities in closed forests where surface burns were cooler and less frequent.

Today, mesic and wet-mesic northern oak forests, woodlands, and savannas are becoming relicts due to fire suppression and other factors that inhibit regeneration. Indeed, these woodlands and savannas represent some of the rarest tree communities in the entire eastern United States (Curtis 1959). Because these stands grew on soils ideal for agriculture, most were cut soon after European settlement. The few stands that survived initial cutting were frequently used as pastures for livestock, resulting in heavy grazing of the understory. Any uncut stands protected from grazing or fire, have been converting to mixed mesophytic forests. At present, most oak woodlands and savannas that resemble their presettlement condition occur along railroad rights-of-way that burn periodically or have been restored to such a condition by thinning and prescribed fire. However, examples of presettlement condition (*e.g.*, tree



◀ *Old-growth mesic oak (black oak, white oak) and a subcanopy of flowering dogwood can be seen at* ***Hemmer Woods*** *in southern Indiana. See McCune* et al. *(1988) and Spetich* et al. *(1996). Photo 4/92 by Lucy Tyrrell.*

composition and density) may still exist on sites influenced by humans, such as old pastures, parks and cemeteries (*e.g.*, Pioneer Cemetery Park, Kalamazoo, MI).

RELATION TO OTHER FOREST TYPES

In most mesic oak forests today, oaks occur only in the canopy, representing the oldest age and largest size classes, whereas the understory is normally dominated by shade-tolerant sugar maple, American beech, white ash (*Fraxinus americana* L.), American basswood (*Tilia americana* L.) and other mesophytic species. Thus, existing oak forests are likely to be replaced by beech-maple-basswood or mesophytic forests in time as shade-tolerant trees replace canopy oaks (Ward and Parker 1989, Shotola *et al.* 1992). To the north, various other hardwoods in combination with northern red oak constitute northern hardwood forests. Mesic forests with a conifer component in addition to oak or other hardwoods would be classified as conifer-northern hardwoods. Oak forests on the dry end of the moisture gradient would be dry-mesic oak forests.

STRUCTURAL CHARACTERISTICS OF OLD-GROWTH STANDS

Information about mesic and wet-mesic northern oak forests, woodlands, and savannas in an old-growth condition is included in Figure 7 and Tables 37 through 46.

SELECTED REPRESENTATIVE OLD-GROWTH STANDS

Illinois

Allerton Park, Piatt Co.
(Boggess and Geis 1967, Johnson and Bell 1975)

Argenta, Macon Co.
(Johnson and Bell 1975)

Baber Woods, Edgar Co.
(Ebinger and McClain 1991, McClain and Ebinger 1968, Newman and Ebinger 1985)

Beall Woods Nature Preserve and State Park, Wabash Co.
(Lindsey 1963, Schmelz 1964)

Boulder Slope Woods, Little Black Slough Natural Area
(Robertson 1987)

Brownfield Woods, Champaign Co.
(Miceli *et al.* 1977)

Foley Woods, East-Central
(Jackson and Petty 1971)

Funk's Grove, McClean Co.
(Boggess and Geis 1965)

George S. Park Memorial Woods, Putnam Co.

Hart Woods, Champaign Co.
(Johnson and Bell 1975)

Middle Fork Woods Nature Preserve, Vermillion Co.

Rocky Branch Nature Preserve, Clark Co.
(Ebinger and Parker 1969)

Sargents Woods, Coles Co.
(Ebinger 1968)

[selected areas in the] Shawnee Hills Region, Southern Illinois
(Fralish *et al.* 1991, Leitner and Jackson 1981)

Iowa

White Pine Hollow, Dubuque Co.

Indiana

Bryan Nature Preserve, Clinton Co.
(Johnson *et al.* 1972)

Central Indiana
(Potzger and Friesner 1940)

Davis Purdue Research Forest, Randolph Co.
(Leopold *et al.* 1985; Parker and Leopold 1983, 1985; Parker *et al.* 1985; Parker and Sherwood 1986; Parker and Ward 1987; Schmelz 1964; Ward and Parker 1989)

Donaldson's Woods, Spring Mill State Park, Lawrence Co.
(Lindsey *et al.* 1969)

Grider's Woods, Tri-County State Fish and Game Area

Hemmer Woods, Gibson Co.
(McCune *et al.* 1988)

James Bird Woods, Harrison Co.
(Lindsey *et al.* 1969, Schmelz and Hodde 1970)

Laughery Creek Valley
(Potzger and Chandler 1952)

Lilly-Dickey Woods, Brown Co.

Mauntel Woods (Stand A), Dubois Co.
(Potzger and Friesner 1934)

Ross Biological Reserve Woods, Tippecanoe Co.
(Schmelz 1964)

Winghaven, Steuben Co.

Kentucky

[selected areas in the] Inner Bluegrass Plateau Region
(Bryant *et al.* 1980)

Big Woods, Mammoth Cave National Park

Maine

Camden Hills State Park, Knox Co.

Michigan

Esker, Southern Michigan near Grass Lake,

Jackson Co.
(Wing 1937)

Pioneer Cemetery Park, Kalamazoo
(Brewer and Kitler 1989)

Radrick Forest, Matthaei Botanical Gardens, Washtenaw Co.
(Hammit and Barnes 1989)

Missouri

Big Oak Tree State Park
(Laughlin 1947)

Ashland Wildlife Area, Boone Co.
(Pallardy *et al.* 1991)

Hickory Canyons Natural Area, Sainte Genevieve Co.

Wegener Woods, Warren Co.

New Jersey

Mettler's Woods (Hutcheson Memorial Forest), Somerset Co.
(Buell 1957; Buell *et al.* 1954; Forman and Elfstrom 1975; Frei and Fairbrothers 1963; Lang and Forman 1978; Monk 1961a, 1961b; Sulser 1971)

Ohio

Cabin Run Forest, Clermont Co.
(Cobbe 1943)

Drew Woods, Darke Co.
(Boerner and Kooser 1991)

Hawk Woods, Athens Co.
(McCarthy *et al.* 1987)

Pennsylvania

Sophia's Woods, Fayette Co.
(Abrams and Downs 1990)

Virginia

[selected areas in the] Shenandoah Valley
(Braun 1950)

Wisconsin

Babcock Oak Opening, Dane Co.
(Stout 1944)

Devil's Lake State Park, Sauk Co.

New Glarus Woods State Park, Green Co.

Noe Woods, U.W. Arboretum
(McCune and Cottam 1985)

Wyalusing State Park, Grant Co.

[site in] Southeastern Wisconsin near Albion
(Bray 1960)

FOR ADDITIONAL INFORMATION

Additional references that pertain to mesic and wet-mesic oak forests, woodlands, and savannas but are not cited in tables or text are listed by forest type group in Appendix C.

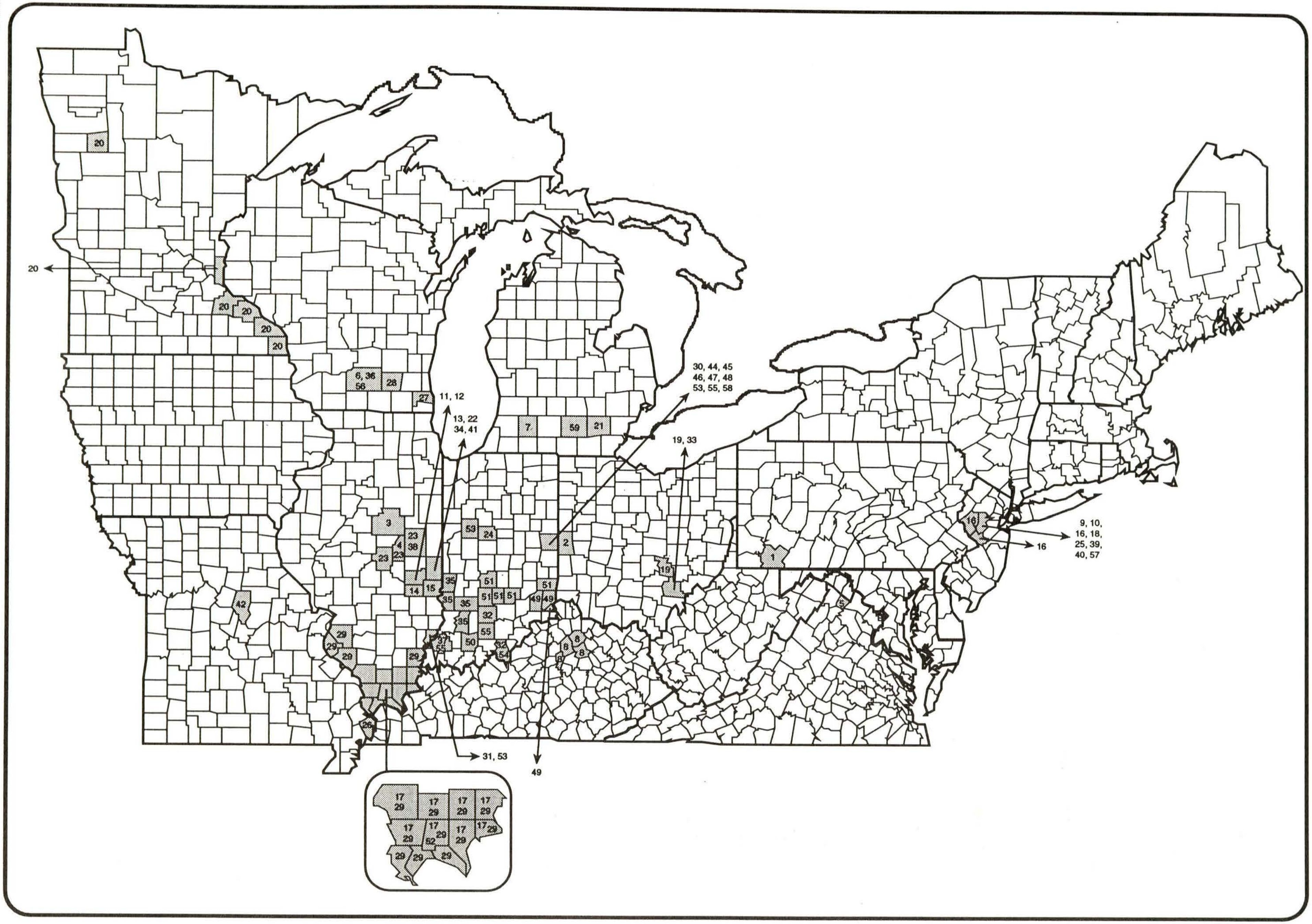

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Figure 7.—*General location of studies that provide stand structure information about old-growth mesic and wet-mesic northern oak forests, woodlands, and savannas. Shaded counties contain at least one study. Numbers correspond to the cited references listed under Map Key below and in Tables 37 through 46. States are indicated using two-letter postal abbreviations. If the citation included information on some counties but not all, this is indicated by the pound sign [#].*

Map Key	Source/Date	State or Province	County
1	Abrams and Downs 1990	PA	Fayette
2	Boerner and Kooser 1991	OH	Darke
3	Boggess and Geis 1965	IL	McClean
4	Boggess and Geis 1967	IL	Piatt
5	Braun 1950	VA	Clarke
6	Bray 1960	WI	Dane
7	Brewer and Kitler 1989	MI	Kalamazoo
8	Bryant et al. 1980	KY	Bourbon, Harrison, Scott, Woodford
9	Buell 1957	NJ	Somerset
10	Buell et al. 1954	NJ	Somerset
11	Ebinger 1968	IL	Coles
12	Ebinger 1987	IL	Coles
13	Ebinger and McClain 1991	IL	Edgar
14	Ebinger and Newman 1984	IL	Cumberland
15	Ebinger and Parker 1969	IL	Clark
16	Forman and Elfstrom 1975	NJ	Somerset, Hunterdon, Mercer
17	Fralish et al. 1991	IL	Gallatin, Hardin, Jackson, Johnson, Pope, Saline, Union, Williamson
18	Frei and Fairbrothers 1963	NJ	Somerset
19	Goebel and Hix 1996	OH	Perry, Athens
20	Hale 1996	MN	Goodhue, Houston, Mahnomen Wabasha, Washington, Winona
21	Hammit and Barnes 1989	MI	Washtenaw
22	Jackson and Petty 1971	IL	Edgar
23	Johnson and Bell 1975	IL	Champaign, Macon, Piatt
24	Johnson et al. 1972	IN	Clinton
25	Lang and Forman 1978	NJ	Somerset
26	Laughlin 1947	MO	Mississippi
27	Leitner 1988d	WI	Racine
28	Leitner 1989a	WI	Jefferson
29	Leitner and Jackson 1981	IL	Alexander, Gallatin, Hardin, Jackson, Johnson, Massac, Monroe, Pope, Pulaski, Randolph, Saline, St. Clair, Union, White, Williamson
30	Leopold et al. 1985	IN	Randolph
31	Lindsey 1963	IL	Wabash
32	Lindsey et al. 1969	IN	Harrison, Lawrence
33	McCarthy et al. 1987	OH	Athens
34	McClain and Ebinger 1968	IL	Edgar
35	McCoy 1939	IN	Vigo, Sullivan, Greene, Daviess
36	McCune and Cottam 1985	WI	Dane
37	McCune et al. 1988	IN	Gibson
38	Miceli et al. 1977	IL	Champaign
39	Monk 1961a	NJ	Somerset
40	Monk 1961b	NJ	Somerset
41	Newman and Ebinger 1985	IL	Edgar
42	Pallardy et al. 1991	MO	Boone
43	Parker 1989	several	#
44	Parker and Leopold 1983	IN	Randolph
45	Parker and Leopold 1985	IN	Randolph
46	Parker and Sherwood 1986	IN	Randolph
47	Parker and Ward 1987	IN	Randolph
48	Parker et al. 1985	IN	Randolph
49	Potzger and Chandler 1952	IN	Dearborn, Ohio, Ripley
50	Potzger and Friesner 1934	IN	Dubois
51	Potzger and Friesner 1940	IN	Bartholomew, Brown, Franklin, Monroe, Morgan
52	Robertson 1987	IL	Johnson
53	Schmelz 1964	IL IN	Wabash Randolph, Tippecanoe
54	Schmelz and Hodde 1970	IN	Harrison
55	Spetich et al. 1996	IN	Gibson, Orange, Randolph
56	Stout 1944	WI	Dane
57	Sulser 1971	NJ	Somerset
58	Ward and Parker 1989	IN	Randolph
59	Wing 1937	MI	Jackson

Table 37.—*Location, size, and elevation of mesic and wet-mesic oak old-growth study sites.*

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
1	Abrams and Downs 1990	Sophia's Woods	PA	Fayette	3	unspecified
2	Boerner and Kooser 1991	Drew Woods	OH	Darke	7	>313
3	Boggess and Geis 1965	Funk Forest Natural Area	IL	McClean	24	unspecified
4	Boggess and Geis 1967	Robert Allerton Park	IL	Piatt	14	unspecified
5	Braun 1950	Shenandoah Valley--Berryville vicinity	VA	Clarke	unspecified	unspecified
6	Bray 1960	Albion Oak Opening	WI	Dane	unspecified	unspecified
7	Brewer and Kitler 1989	Pioneer Cemetery Park	MI	Kalamazoo	0.9	unspecified
7	Brewer and Kitler 1989	Presettlement Michigan bur oak openings	MI	Kalamazoo	~0.9	unspecified
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand A	KY	Scott	unspecified	} 244-305 [1]
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand B	KY	Woodford	unspecified	}
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand C	KY	Harrison	unspecified	}
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand D	KY	Bourbon	unspecified	}
9	Buell 1957	Mettler's Woods [Hutcheson] [2]	NJ	Somerset	26	unspecified
10	Buell et al. 1954	Mettler's Woods [Hutcheson] [2]	NJ	Somerset	26	unspecified
11	Ebinger 1968	Sargents Woods	IL	Coles	10	unspecified
12	Ebinger 1987	Presettlement oak forests in Illinois	IL	Coles	entire county	unspecified
13	Ebinger and McClain 1991	Baber Woods Nature Preserve-1990	IL	Edgar	16	unspecified
14	Ebinger and Newman 1984	Embarass River--dry-mesic upland forest	IL	Cumberland	8	unspecified
15	Ebinger and Parker 1969	Rocky Branch Nature Preserve	IL	Clark	6.5	200
16	Forman and Elfstrom 1975	Hutcheson Memorial Forest	NJ	Somerset	24	20-100
16	Forman and Elfstrom 1975	Maryknoll Farm East	NJ	Hunterdon	10	20-100
16	Forman and Elfstrom 1975	Maryknoll Farm West	NJ	Hunterdon	8	20-100
16	Forman and Elfstrom 1975	Reno Farm	NJ	Hunterdon	10	20-100
16	Forman and Elfstrom 1975	Ringoes Corso Woods	NJ	Hunterdon	10	20-100
16	Forman and Elfstrom 1975	Water Tower Woods	NJ	Somerset	8	20-100
16	Forman and Elfstrom 1975	Western Electric Woods	NJ	Mercer	24	20-100
16	Forman and Elfstrom 1975	Wohendorf-Perry Woods	NJ	Hunterdon	8	20-100
17	Fralish et al. 1991	Shawnee Hills--presettlement ridgetop	IL	several [3]	240,000	unspecified
17	Fralish et al. 1991	Shawnee Hills--old-growth ridgetop	IL	several [3]	240,000	unspecified
18	Frei and Fairbrothers 1963	Hutcheson Memorial Forest	NJ	Somerset	26	unspecified
19	Goebel and Hix 1996	Hawk Woods, Ketcham Woods, Strouds Run	OH	Athens, Perry [4]	>0.4 ha	243-291
20	Hale 1996	10 oak stands in Minnesota	MN	several [5]	4-44	265-567
20	Hale 1996	Arrowpoint	MN	Mahnomen	16	567
20	Hale 1996	Caledonia OG	MN	Houston	8	299
20	Hale 1996	Denmark	MN	Washington	44	265
20	Hale 1996	Evers	MN	Wabasha	32	326
20	Hale 1996	Hientz 25	MN	Houston	6	302

(Table 37 continued on next page)

(Table 37 continued)

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
20	Hale 1996	Leon 9	MN	Goodhue	4	357
20	Hale 1996	Melcher Ridge	MN	Winona	36	290
20	Hale 1996	Sheldon 27	MN	Houston	18	299
20	Hale 1996	White Water	MN	Winona	10	323
20	Hale 1996	Zimmerman	MN	Winona	8	299
21	Hammit and Barnes 1989	Radrick Forest--1968	MI	Washtenaw	14	unspecified
21	Hammit and Barnes 1989	Radrick Forest--1988	MI	Washtenaw	14	unspecified
22	Jackson and Petty 1971	Foley Woods	IL	Edgar	32	unspecified
23	Johnson and Bell 1975	3 streamside forests in Illinois [6]	IL	Champaign, Macon, Piatt	unspecified	unspecified
24	Johnson et al. 1972	Bryan Nature Preserve	IN	Clinton	11	unspecified
25	Lang and Forman 1978	Hutcheson Memorial Forest	NJ	Somerset	26	unspecified
26	Laughlin 1947	Big Oak Tree State Park	MO	Mississippi	408	unspecified
27	Leitner 1988d	Sanders Park Hardwoods	WI	Racine	12	unspecified
28	Leitner 1989a	Blue Spring Oak Opening	WI	Jefferson	8	unspecified
29	Leitner and Jackson 1981	Presettlement forests of unglaciated Illinois	IL	several [7]	738,150 [8]	unspecified
30	Leopold et al. 1985	Davis-Purdue Research Forest	IN	Randolph	21	293 - 296
31	Lindsey 1963	Beall Woods	IL	Wabash	113	122
32	Lindsey et al. 1969	Donaldson's Woods/Spring Mill State Park	IN	Lawrence	32	unspecified
32	Lindsey et al. 1969	James Bird Woods	IN	Harrison	18	unspecified
33	McCarthy et al. 1987	Hawk Woods--white oak	OH	Athens	35	unspecified
33	McCarthy et al. 1987	Hawk Woods--oak-hickory	OH	Athens	35	unspecified
34	McClain and Ebinger 1968	Baber Woods--1964	IL	Edgar	21	230 - 244
35	McCoy 1939	Illinoian Till Plain--Forests Q-Y	IN	several [9]	9 forests	unspecified
36	McCune and Cottam 1985	Noe Woods--1956	WI	Dane	10	unspecified
36	McCune and Cottam 1985	Noe Woods--1968	WI	Dane	10	unspecified
36	McCune and Cottam 1985	Noe Woods--1983	WI	Dane	10	unspecified
37	McCune et al. 1988	Hemmer Woods	IN	Gibson	~27	unspecified
38	Miceli et al. 1977	Big Grove--Brownfield Woods	IL	Champaign	24	unspecified
39	Monk 1961a	Hutcheson Memorial Forest--upland	NJ	Somerset	22 [10]	unspecified
40	Monk 1961b	Hutcheson Memorial Forest--upland	NJ	Somerset	22 [10]	unspecified
41	Newman and Ebinger 1985	Baber Woods--1983	IL	Edgar	21	230 - 244
42	Pallardy et al. 1991	Ashland Wildlife Area--mesic slope 1968	MO	Boone	890	unspecified
42	Pallardy et al. 1991	Ashland Wildlife Area--mesic slope 1982	MO	Boone	890	unspecified
43	Parker 1989	Central Hardwood Region--mesic uplands	central states	unspecified	unspecified	unspecified
44	Parker and Leopold 1983	Davis-Purdue Research Forest--1976	IN	Randolph	21	293 - 296
45	Parker and Leopold 1985	Davis-Purdue Research Forest--1926-1976	IN	Randolph	21	293 - 296
46	Parker and Sherwood 1986	Davis-Purdue Research Forest--1985	IN	Randolph	21	293 - 296

(Table 37 continued on next page)

(Table 37 continued)

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
47	Parker and Ward 1987	Davis-Purdue Research Forest--1976	IN	Randolph	21	293 - 296
48	Parker et al. 1985	Davis-Purdue Research Forest--1976	IN	Randolph	21	293 - 296
49	Potzger and Chandler 1952	Gilbert Lubbe Woods	IN	Dearborn, Ripley	unspecified	unspecified
49	Potzger and Chandler 1952	John Burman Woods	IN	Ohio	unspecified	unspecified
49	Potzger and Chandler 1952	Fred Harting Woods	IN	Dearborn, Ripley	unspecified	unspecified
49	Potzger and Chandler 1952	Lemon Woods	IN	Ripley	unspecified	unspecified
50	Potzger and Friesner 1934	Mauntel Woods--Section A	IN	Dubois	6	unspecified
51	Potzger and Friesner 1940	14 forests in central Indiana	IN	several [11]	9	unspecified
52	Robertson 1987	Boulder Slope Woods--mid-slope	IL	Johnson	100	<60
53	Schmelz 1964	Beall Woods--upland (Stand 13)	IL	Wabash	2	unspecified
53	Schmelz 1964	Davis Forestry Farm Woods (Stand 6)	IN	Randolph	19	293 - 296
53	Schmelz 1964	Ross Biological Reserve Woods (Stand 7)	IN	Tippecanoe	5	unspecified
54	Schmelz and Hodde 1970	James Bird Woods	IN	Harrison	12	unspecified
55	Spetich et al. 1996	Davis-Purdue Research Forest	IN	Randolph	21	293 - 296
55	Spetich et al. 1996	Hemmer Woods	IN	Gibson	26	unspecified
55	Spetich et al. 1996	Pioneer Mothers	IN	Orange	15	unspecified
56	Stout 1944	Babcock Oak Opening	WI	Dane	20	unspecified
57	Sulser 1971	Hutcheson Memorial Forest--1969 [12]	NJ	Somerset	26	unspecified
58	Ward and Parker 1989	Davis-Purdue Research Forest--1986	IN	Randolph	21	293 - 296
59	Wing 1937	Oak openings in vicinity of Grass Lake	MI	Jackson	unspecified	unspecified

[1] Range of elevations for all stands studied.

[2] Now called Hutcheson Memorial Forest.

[3] Counties were: Gallatin, Hardin, Jackson, Johnson, Pope, Saline, Union, Williamson.

[4] Near Athens Unit of Wayne National Forest.

[5] Counties were: Goodhue, Houston, Mahnomen, Wabasha, Washington, Winona.

[6] Forest stands are Hart Woods, Allerton Park, and Argenta, all located along the Sangamon River.

[7] Counties were: Alexander, Gallatin, Hardin, Jackson, Johnson, Massac, Monroe, Pope, Pulaski, Randolph, Saline, St. Clair, Union, White, Williamson.

[8] Area is bounded by glacial border and rivers: Ohio, Mississippi, and Wabash.

[9] Counties were: Daviess, Greene, Sullivan, Vigo.

[10] 82% of total 26 ha is upland.

[11] Counties were: Bartholomew, Brown, Franklin, Monroe, Morgan.

[12] Paper gives data from 1950 also; not presented here.

Table 38.—*Criteria used by sources to identify old-growth stands, and information about stand composition of mesic and wet-mesic oak old-growth study sites.*

Map Key	Source/Date	Stand	Criteria for Stand Selection and Stand Composition
1	Abrams and Downs 1990	Sophia's Woods	Old-growth remnant; some stumps; beech-red maple-tulip tree-oak (18%) [1]
2	Boerner and Kooser 1991	Drew Woods	Old-growth remnant; undisturbed [2]; white oak (55%)-hickory (11%)-white ash (18%)
3	Boggess and Geis 1965	Funk Forest Natural Area	Protected remnant [3]; sugar maple (27%)-white oak (25%); transition to mesic [4]
4	Boggess and Geis 1967	Robert Allerton Park	Virgin condition; white oak (34%)-black oak (24%)-red oak-hickory
5	Braun 1950	Shenandoah Valley--Berryville vicinity	Old-growth primary forest; white oak (63%)-hickory
6	Bray 1960	Albion Oak Opening	Undisturbed savanna [5]; <60% canopy; understory grazed; bur oak (100%)
7	Brewer and Kitler 1989	Pioneer Cemetery Park	Bur oak opening in cemetery; disturbed [6]; bur oak-black oak-white oak-hickory
7	Brewer and Kitler 1989	Presettlement Michigan bur oak openings	Bur oak opening reconstructed from surveyors' notes
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand A	Remnant stand; understory grasses disturbed; blue ash [7]-bur oak-shumard oak
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand B	Remnant stand; understory grasses disturbed; blue ash [7]-bur oak-shumard oak
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand C	Remnant stand; understory grasses disturbed; blue ash [7]-bur oak-shumard oak
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand D	Remnant stand; understory grasses disturbed; blue ash [7]-bur oak-shumard oak
9	Buell 1957	Mettler's Woods [Hutcheson]	Fragment of original forest; never cut or cleared [8,9,10]; white oak-black oak-red oak-hickory
10	Buell et al. 1954	Mettler's Woods [Hutcheson]	Fragment of original forest; never cut or cleared [8,9,10]; white oak-black oak-red oak-hickory
11	Ebinger 1968	Sargents Woods	Remnant in natural state; no grazing, 172 oaks cut in 1948; white oak-white ash-red oak
12	Ebinger 1987	Presettlement oak forests in Illinois	Presettlement forest [11]; white oak (37%)-black oak (24%)-hickories-red oak
13	Ebinger and McClain 1991	Baber Woods Nature Preserve-1990	Formerly open, upland savanna, periodic fires [12]; with increasing sugar maple; oaks-sugar maple
14	Ebinger and Newman 1984	Embarass River--dry-mesic upland forest	Forest remnant; some cutting [13]; white oak-black oak-hickories-sugar maple
15	Ebinger and Parker 1969	Rocky Branch Nature Preserve	Remnant forest; some grazing, cutting; white oak (47%)-black oak (13%)-red oak (12%)
16	Forman and Elfstrom 1975	Hutcheson Memorial Forest	Old woods; unburned for 300 yr; uncut; white oak (24%)-red oak (17%)-dogwood (36%) [14]
16	Forman and Elfstrom 1975	Maryknoll Farm East	Mature trees 60-100 cm d.b.h.; lack of disturbance; red oak (22%)-black oak (16%)-white oak (14%) [14]
16	Forman and Elfstrom 1975	Maryknoll Farm West	Mature trees 60-100 cm d.b.h.; lack of disturbance; black oak (23%)-beech (17%) [14]
16	Forman and Elfstrom 1975	Reno Farm	Mature trees 60-100 cm d.b.h.; lack of disturbance; red oak (33%)-white oak (26%)-black oak (25%) [14]
16	Forman and Elfstrom 1975	Ringoes Corso Woods	Mature trees 60-100 cm d.b.h.; lack of disturbance; sugar maple (21%)-ash (17%)-black oak (15%) [14]
16	Forman and Elfstrom 1975	Water Tower Woods	Mature trees 60-100 cm d.b.h.; lack of disturbance; black oak (45%)-white oak (26%) [14]
16	Forman and Elfstrom 1975	Western Electric Woods	Mature trees 60-100 cm d.b.h.; lack of disturbance; red oak (23%)-sugar maple (15%)-white oak (15%) [14]
16	Forman and Elfstrom 1975	Wohendorf-Perry Woods	Mature trees 60-100 cm d.b.h.; lack of disturbance; red oak (23%)-white oak (23%) [14]
17	Fralish et al. 1991	Shawnee Hills--presettlement ridgetop	Presettlement forest [15,16]; ridgetop community of white oak (45%)-black oak (33%)
17	Fralish et al. 1991	Shawnee Hills--old-growth ridgetop	Old growth [17]; white oak (54%)-black oak (12%)
18	Frei and Fairbrothers 1963	Hutcheson Memorial Forest	Mature oak; 299 trees removed after storm in 1951; white oak-red oak-black oak
19	Goebel and Hix 1996	Hawk Woods, Ketcham Woods, Strouds Run	>150 yr, no major disturbance within past 80 yr; white oak (36%)-chestnut oak (24%)
20	Hale 1996	10 oak stands in Minnesota	>120 yr; no significant natural or human induced disturbance [18]
20	Hale 1996	Arrowpoint	>120 yr; no significant natural or human induced disturbance [18]; 8% oaks
20	Hale 1996	Caledonia OG	>120 yr; no significant natural or human induced disturbance [18]; 35% oaks
20	Hale 1996	Denmark	>120 yr; no significant natural or human induced disturbance [18]; 32% oaks
20	Hale 1996	Evers	>120 yr; no significant natural or human induced disturbance [18]; 39% oaks
20	Hale 1996	Hientz 25	>120 yr; no significant natural or human induced disturbance [18]; 75% oaks

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(Table 38 continued)

Map Key	Source/Date	Stand	Criteria for Stand Selection and Stand Composition
20	Hale 1996	Leon 9	>120 yr; no significant natural or human induced disturbance [18]; 37% oaks
20	Hale 1996	Melcher Ridge	>120 yr; no significant natural or human induced disturbance [18]; 79% oaks
20	Hale 1996	Sheldon 27	>120 yr; no significant natural or human induced disturbance [18]; 39% oaks
20	Hale 1996	White Water	>120 yr; no significant natural or human induced disturbance [18]; 48% oaks
20	Hale 1996	Zimmerman	>120 yr; no significant natural or human induced disturbance [18]; 53% oaks
21	Hammit and Barnes 1989	Radrick Forest--1968	150 yr old forest; heavily cut in 1820's; white oak (44%)-black oak (27%) [19]
21	Hammit and Barnes 1989	Radrick Forest--1988	150 yr old forest; heavily cut in 1820's; white oak (45%)-black oak (28%) [20]
22	Jackson and Petty 1971	Foley Woods	Little disturbed; some selective cutting [21]; sugar maple (21%)-red oak (13%)-bur oak (11%)
23	Johnson and Bell 1975	3 streamside forests in Illinois	Upland forests that escaped some degree of logging [22]; oak-hickory
24	Johnson et al. 1972	Bryan Nature Preserve	Old growth; relatively undisturbed [23]; white oak (25%)-red oak (15%)
25	Lang and Forman 1978	Hutcheson Memorial Forest	Old-age forest; uncut and unburned for >250 yr; mixed oak
26	Laughlin 1947	Big Oak Tree State Park	Virgin timber; bur oak
27	Leitner 1988d	Sanders Park Hardwoods	State significant dry-mesic forest; basswood-white oak-walnut-red oak
28	Leitner 1989a	Blue Spring Oak Opening	One of least disturbed oak openings in state; some grazing; bur oak-black oak
29	Leitner and Jackson 1981	Presettlement forests of unglaciated Illinois	Presettlement forests; white oak (29%)-black oak (12%)-hickory (9%)
30	Leopold et al. 1985	Davis-Purdue Research Forest	Old growth; relatively undisturbed [24]; red oak (29%)-white oak (13%)-bur oak (12%)
31	Lindsey 1963	Beall Woods	Old-growth hardwood upland remnant; white oak (48%)
32	Lindsey et al. 1969	Donaldson's Woods/Spring Mill State Park	Virgin woods; some windthrow logs removed [25]; white oak (49%)
32	Lindsey et al. 1969	James Bird Woods	Large oaks, tulip trees; some cutting in 1963 [26]; grazing; black oak-white oak
33	McCarthy et al. 1987	Hawk Woods--white oak	Old-growth forest; perhaps some selective tree removal or grazing.
33	McCarthy et al. 1987	Hawk Woods--oak-hickory	Old-growth forest; perhaps some selective tree removal or grazing.
34	McClain and Ebinger 1968	Baber Woods--1964	Relatively undisturbed remnant [27]; white oak (54%)-pignut hickory (16%)-black oak (15%)
35	McCoy 1939	Illinoian Till Plain--Forests Q-Y	Climax forest [28]; least disturbed; oak-hickory-elm
36	McCune and Cottam 1985	Noe Woods--1956	Oak savanna <1840; cutting in 1900-10 [29]; white oak (44%)-black oak (52%)-black cherry (1%)
36	McCune and Cottam 1985	Noe Woods--1968	Oak savanna <1840; cutting in 1900-10 [29]; white oak (45%)-black oak (48%)-black cherry (3%)
36	McCune and Cottam 1985	Noe Woods--1983	Oak savanna <1840; cutting in 1900-10 [29]; white oak (52%)-black oak (36%) [30]-black cherry (6%)
37	McCune et al. 1988	Hemmer Woods	Old-growth woods; human impacts [31] minor; white oak (37%)-black oak (18%)-red oak (9%)
38	Miceli et al. 1977	Big Grove--Brownfield Woods	Prairie grove forest remnant; sugar maple (41%)-red oak (26%)-bur oak (9%)
39	Monk 1961a	Hutcheson Memorial Forest--upland	Mature forest; fire suppression; removal of some fallen trees; white and black oak (total 68%)
40	Monk 1961b	Hutcheson Memorial Forest--upland	Mature forest; near-climax [32]; white oak (52%)-black oak (22%)-red and scarlet (12%) [33]
41	Newman and Ebinger 1985	Baber Woods--1983	Relatively undisturbed since 1898; white oak (34%)-sugar maple (16%)-pignut hickory (15%)
42	Pallardy et al. 1991	Ashland Wildlife Area--mesic slope 1968	Reserve, second-growth hardwoods with trees 65-150 yr
42	Pallardy et al. 1991	Ashland Wildlife Area--mesic slope 1982	Reserve, second-growth hardwoods with trees 65-150 yr
43	Parker 1989	Central Hardwood Region--mesic uplands	Trees >150 yr; little disturbance in last 80-100 yr; multi-layered; mesic deciduous [34]
44	Parker and Leopold 1983	Davis-Purdue Research Forest--1976	Mature tract [35]; significant elm mortality; red oak (29%)-white oak (13%)-bur oak (12%) [36]
45	Parker and Leopold 1985	Davis-Purdue Research Forest--1926-1976	Mature deciduous forest; significant elm mortality
46	Parker and Sherwood 1986	Davis-Purdue Research Forest--1985	Old growth; some grazing <1917 [37]; oak-dominated

(Table 38 continued on next page)

(Table 38 continued)

Map Key	Source/Date	Stand	Criteria for Stand Selection and Stand Composition
47	Parker and Ward 1987	Davis-Purdue Research Forest--1976	Old growth [38]; some grazing <1917 [39]; red oak (21%)-white ash (17%)-bur oak (14%) [40]
48	Parker et al. 1985	Davis-Purdue Research Forest--1976	Old growth; red oak (29%)-white oak (13%)-bur oak (12%) [41]
49	Potzger and Chandler 1952	Gilbert Lubbe Woods	Little disturbance; white oak- red oak
49	Potzger and Chandler 1952	John Burman Woods	Little disturbance; white oak-black oak
49	Potzger and Chandler 1952	Fred Harting Woods	Little disturbance; white oak-chinkapin oak-red oak
49	Potzger and Chandler 1952	Lemon Woods	Little disturbance; chinkapin oak-red oak
50	Potzger and Friesner 1934	Mauntel Woods--Section A	Virgin forest; undisturbed; white oak-ash-hickory
51	Potzger and Friesner 1940	14 forests in central Indiana	Unspecified*; south-facing or ridge oak-hickory forests
52	Robertson 1987	Boulder Slope Woods--mid-slope	Relatively undisturbed [42]; white oak (25%)-red oak (13%)-hickory (30%) [43]
53	Schmelz 1964	Beall Woods--upland (Stand 13)	Considered undisturbed [44]; white oak
53	Schmelz 1964	Davis Forestry Farm Woods (Stand 6)	Considered undisturbed; some cutting <1926 [45]; oaks
53	Schmelz 1964	Ross Biological Reserve Woods (Stand 7)	Considered undisturbed; white oak (21%)-black oak (13%)
54	Schmelz and Hodde 1970	James Bird Woods	Old growth; some cutting 1922, 1963 [46]; oak-hickory
55	Spetich et al. 1996	Davis-Purdue Research Forest	>150 yr; minimal human disturbance in last 80-100 yr
55	Spetich et al. 1996	Hemmer Woods	>150 yr; minimal human disturbance in last 80-100 yr
55	Spetich et al. 1996	Pioneer Mothers	>150 yr; minimal human disturbance in last 80-100 yr
56	Stout 1944	Babcock Oak Opening	Good preservation; grazing; bur oak (100%)
57	Sulser 1971	Hutcheson Memorial Forest--1969	Old oak forest; natural area; oaks
58	Ward and Parker 1989	Davis-Purdue Research Forest--1986	Old-growth forest; grazed <1917; some harvest, fire [47]
59	Wing 1937	Oak openings in vicinity of Grass Lake	Ancient oak openings; white oak

[1] Stand in late stages of succession to mixed mesophytic.

[2] No cutting or significant disturbance since family acquired area in 1855.

[3] Protected since 1950 as natural area.

[4] Transition to sugar maple and other mesic species.

[5] This site was one of 60 savannas studied (some mesic, some dry, some dry-mesic).

[6] Site is not undisturbed--there have been burials, and tree clearings to promote grass.

[7] Blue ash distinquishes Kentucky savanna-woodlands.

[8] Damaged and downed timber often salvaged except from natural area.

[9] Lenape Indians would burn deliberately (1627-1711).

[10] Trees originated during period of frequent fires.

[11] Coles County was 60% prairie, 40% forest.

[12] Fire scars at 65 and 77 yr before present.

[13] Fifteen stumps of white oak and black walnut indicate relatively recent cutting.

[14] Percent composition based on basal area.

[15] Presettlement forest community reconstructed from Government Land Office survey, 1806-07.

[16] Cutting and fire in late 1800s.

[17] Current old growth and presettlement are different because current old growth has not experienced fire disturbance.

[18] No visible evidence of such disturbance.

[19] Percent composition based on density of trees >10 cm d.b.h.

(Table 38 continued on next page)

(Table 38 continued)

[20] Percent composition based on density of canopy dominants.

[21] Removal of walnut, oak, hickory in 1930s and 1940s.

[22] All logged or selectively cut in early mid- to late mid-1800s.

[23] Selectively logged >30 yr ago.

[24] Grazed <1917; limited cutting of dead or dying trees in 1940-50s; small surface fire in western portion in 1972.

[25] No commercial lumbering; no evidence of fire >1906.

[26] Only damaged trees removed from 1922 to 1963. Removal of 8600 board feet in 1963.

[27] Relatively undisturbed since 1898; never grazed.

[28] Forests of western lobe of Illinoian Till Plain.

[29] Limited cutting was followed by stump sprouting.

[30] Black oak has been greatly affected by oak wilt.

[31] Direct human impacts.

[32] Storms in 1950 & 1956 blew over more than 300 large trees.

[33] Percent composition based on basal area.

[34] Includes forest types other than just oaks.

[35] Subject to grazing prior to 1917; no timber cut for commercial use.

[36] Percent composition based on basal area >10 cm.

[37] Some dead/dying trees removed in mid-1900s.

[38] One of the finest old-growth stands remaining on the Tipton Till Plain.

[39] Some dead and dying trees harvested prior to 1960; fire in 2-3 ha in western part of forest in 1971.

[40] Percent composition based on density of trees >50 cm d.b.h.

[41] Percent composition based on basal area >10 cm.

[42] Light selective logging in the past.

[43] Percent composition based on basal area >6.6 cm d.b.h.

[44] Very few trees removed from tract.

[45] Only defective or damaged trees cut; no evidence of grazing or fire.

[46] Tract used for grazing, crops, lumber; now natural reserve.

[47] Some dead and dying trees harvested in 1940s and 50s; fire on 2-3 ha in 1971.

Table 39.—*Methods used to study old-growth mesic and wet-mesic oaks (condensed from the cited references).*

Map Key	Source/Date	Stand	Possible Confusion with These Types	Sampling Methods
1	Abrams and Downs 1990	Sophia's Woods	mixed mesophytic [1]	20 points, point quarter method; 61 cores
2	Boerner and Kooser 1991	Drew Woods	lowland is hardwood wetland	25 10 m x 10 m plots along 4 random N-S transects
3	Boggess and Geis 1965	Funk Forest Natural Area	transitional mixed mesophytic	96 50-m^2 sample blocks
4	Boggess and Geis 1967	Robert Allerton Park		63 50-m^2 sample blocks
5	Braun 1950	Shenandoah Valley--Berryville vicinity		Unspecified
6	Bray 1960	Albion Oak Opening		20 points using random pairs technique
7	Brewer and Kitler 1989	Pioneer Cemetery Park		Fully tally in park, nearest neighbor analysis using Clark-Evens method
7	Brewer and Kitler 1989	Presettlement Michigan bur oak openings		Notes of original land survey of 1827 for bur oak opening at cemetery
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand A	mixed mesophytic	Tally of all trees >20 cm
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand B	mixed mesophytic	Tally of all trees >20 cm
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand C	mixed mesophytic	Point quarter method
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand D	mixed mesophytic	Point quarter method
9	Buell 1957	Mettler's Woods [Hutcheson]	dry-mesic [2]	Unspecified
10	Buell et al. 1954	Mettler's Woods [Hutcheson]	dry-mesic [2]	Analysis of large windthrown white oak
11	Ebinger 1968	Sargents Woods		Tally of trees, snags and logs in 50-m^2 blocks in entire woodlot
12	Ebinger 1987	Presettlement oak forests in Illinois	other oak forests	General Land Office survey records (1252 witness trees) [3]
13	Ebinger and McClain 1991	Baber Woods Nature Preserve-1990	oak-mesophytic change	1990 walk-through survey of open-grown white oaks; 1965 and 1983 survey
14	Ebinger and Newman 1984	Embarass River--dry-mesic upland forest	dry-mesic with maple	126 25 m x 25 m quadrats
15	Ebinger and Parker 1969	Rocky Branch Nature Preserve		50 m x 50 m quadrats
16	Forman and Elfstrom 1975	Hutcheson Memorial Forest	[2]	116 40 m x 10 m quadrats; 4 10 m x 90 m transects
16	Forman and Elfstrom 1975	Maryknoll Farm East		55 40 m x 10 m quadrats; 14 10 m x 90 m transects
16	Forman and Elfstrom 1975	Maryknoll Farm West		10 40 m x 10 m quadrats; 3 10 m x 90 m transects
16	Forman and Elfstrom 1975	Reno Farm		10 40 m x 10 m quadrats; 3 10 m x 90 m transects
16	Forman and Elfstrom 1975	Ringoes Corso Woods		10 40 m x 10 m quadrats; 3 10 m x 90 m transects
16	Forman and Elfstrom 1975	Water Tower Woods		45 40 m x 10 m quadrats; 8 10 m x 90 m transects
16	Forman and Elfstrom 1975	Western Electric Woods		10 40 m x 10 m quadrats; 3 10 m x 90 m transects
16	Forman and Elfstrom 1975	Wohendorf-Perry Woods		10 40 m x 10 m quadrats; 3 10 m x 90 m transects
17	Fralish et al. 1991	Shawnee Hills--presettlement ridgetop		0.04 ha circular plots, random
17	Fralish et al. 1991	Shawnee Hills--old-growth ridgetop	without fire, now more mesic	Predicted from Fralish (1988)
18	Frei and Fairbrothers 1963	Hutcheson Memorial Forest		Report of large tree which fell in 1950 hurricane
19	Goebel and Hix 1996	Hawk Woods, Ketcham Woods, Strouds Run	dry-mesic	2 500-m^2 plots per stand; 2 stands in Hawk Woods; 3-5 cores per stand
20	Hale 1996	10 oak stands in Minnesota	dry-mesic	1 20 m x 50 m plot; plus 4 2 m x 100 m belt transects; 10 cores (each stand)
20	Hale 1996	Arrowpoint	dry-mesic	1 20 m x 50 m plot; plus 4 2 m x 100 m belt transects; 10 cores
20	Hale 1996	Caledonia OG	dry-mesic	1 20 m x 50 m plot; plus 4 2 m x 100 m belt transects; 10 cores
20	Hale 1996	Denmark	dry-mesic	1 20 m x 50 m plot; plus 4 2 m x 100 m belt transects; 10 cores
20	Hale 1996	Evers	dry-mesic	1 20 m x 50 m plot; plus 4 2 m x 100 m belt transects; 10 cores
20	Hale 1996	Hientz 25	dry-mesic	1 20 m x 50 m plot; plus 4 2 m x 100 m belt transects; 10 cores

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(Table 39 continued)

Map Key	Source/Date	Stand	Possible Confusion with These Types	Sampling Methods
20	Hale 1996	Leon 9	dry-mesic	1 20 m x 50 m plot; plus 4 2 m x 100 m belt transects; 10 cores
20	Hale 1996	Melcher Ridge	dry-mesic	1 20 m x 50 m plot; plus 4 2 m x 100 m belt transects; 10 cores
20	Hale 1996	Sheldon 27	dry-mesic	1 20 m x 50 m plot; plus 4 2 m x 100 m belt transects; 10 cores
20	Hale 1996	White Water	dry-mesic	1 20 m x 50 m plot; plus 4 2 m x 100 m belt transects; 10 cores
20	Hale 1996	Zimmerman	dry-mesic	1 20 m x 50 m plot; plus 4 2 m x 100 m belt transects; 10 cores
21	Hammit and Barnes 1989	Radrick Forest--1968	succession to mesophytic	25 random 20 m x 10 m plots; 3.2-ha strip cruise
21	Hammit and Barnes 1989	Radrick Forest--1988	succession to mesophytic	25 random 20 m x 10 m plots (resampled)
22	Jackson and Petty 1971	Foley Woods	succession to mesophytic	40 0.08-ha line strips, for 10% sample
23	Johnson and Bell 1975	3 streamside forests in Illinois	forests border floodplain	60-m diameter circular plots at 50-m intervals along transects
24	Johnson et al. 1972	Bryan Nature Preserve	[3]	0.1-ha quadrats, for total forest inventory (10.9 ha)
25	Lang and Forman 1978	Hutcheson Memorial Forest		Fallen boles tallied in 24 400-m^2 quadrats in 1.5 ha study area
26	Laughlin 1947	Big Oak Tree State Park	Mississippi River bottomland	Big tree measurements
27	Leitner 1988d	Sanders Park Hardwoods	dry-mesic oak	20 10 m x 25 m quadrats
28	Leitner 1989a	Blue Spring Oak Opening		20 10 m x 25 m quadrats
29	Leitner and Jackson 1981	Presettlement forests of unglaciated Illinois		General Land Office survey (1805-1815) in random pairs
30	Leopold et al. 1985	Davis-Purdue Research Forest		1976 remeasurement of 21 0.4-ha plots
31	Lindsey 1963	Beall Woods		25 0.08-ha strip plots in stratefied random design
32	Lindsey et al. 1969	Donaldson's Woods/Spring Mill State Park	western mesophytic	Complete census of 8 ha
32	Lindsey et al. 1969	James Bird Woods		Measurements of some trees >76 cm
33	McCarthy et al. 1987	Hawk Woods--white oak		14 100-m^2 circular plots along elevational contour
33	McCarthy et al. 1987	Hawk Woods--oak-hickory		14 100-m^2 circular plots along elevational contour
34	McClain and Ebinger 1968	Baber Woods--1964	succession to mesophytic	Entire woodlot divided into 50 m x 50 m blocks
35	McCoy 1939	Illinoian Till Plain--Forests Q-Y		20 10 m x 10 m quadrats in each forest
36	McCune and Cottam 1985	Noe Woods--1956		Tallies in 15.2 m x 15.2 m units in 137 m x 137 m grid
36	McCune and Cottam 1985	Noe Woods--1968		Tallies in 15.2 m x 15.2 m units in 137 m x 137 m grid
36	McCune and Cottam 1985	Noe Woods--1983		Tallies in 15.2 m x 15.2 m units in 137 m x 137 m grid
37	McCune et al. 1988	Hemmer Woods		68 100-m^2 circular plots on 50-m grid
38	Miceli et al. 1977	Big Grove--Brownfield Woods	mesophytic	90 50-m^2 blocks
39	Monk 1961a	Hutcheson Memorial Forest--upland	[2,4]	Complete census using strips 10-15 m wide
40	Monk 1961b	Hutcheson Memorial Forest--upland	[2,4]	Full survey; forest divided into strips; notes on gap closure
41	Newman and Ebinger 1985	Baber Woods--1983	includes other forests types [5,6]	50 m x 50 m quadrats
42	Pallardy et al. 1991	Ashland Wildlife Area--mesic slope 1968	transition to maple, mesophytic	15 nested circular 0.08-ha plots [7]
42	Pallardy et al. 1991	Ashland Wildlife Area--mesic slope 1982	transition to maple, mesophytic	15 nested circular 0.08-ha plots [7]
43	Parker 1989	Central Hardwood Region--mesic uplands	includes other mesic types [8]	Gives characteristics from published literature sources
44	Parker and Leopold 1983	Davis-Purdue Research Forest--1976		Remeasurement of 21 0.4-ha quadrats in central 8.5 ha
45	Parker and Leopold 1985	Davis-Purdue Research Forest--1926-1976		Remeasurement of 21 0.4-ha quadrats in central 8.5 ha
46	Parker and Sherwood 1986	Davis-Purdue Research Forest--1985		Diameters of trees adjacent to 2 canopy gaps in central 8.5 ha

(Table 39 continued on next page)

(Table 39 continued)

Map Key	Source/Date	Stand	Possible Confusion with These Types	Sampling Methods
47	Parker and Ward 1987	Davis-Purdue Research Forest--1976	succession to maple	400 10 m x 10 m quadrats (100% inventory) in east 4 ha of interior study area
48	Parker et al. 1985	Davis-Purdue Research Forest--1976	oaks decreasing	Remeasurement of 21 0.4-ha quadrats in central 8.5 ha
49	Potzger and Chandler 1952	Gilbert Lubbe Woods		20 10 m x 10 m quadrats
49	Potzger and Chandler 1952	John Burman Woods		20 10 m x 10 m quadrats
49	Potzger and Chandler 1952	Fred Harting Woods		20 10 m x 10 m quadrats
49	Potzger and Chandler 1952	Lemon Woods		20 10 m x 10 m quadrats
50	Potzger and Friesner 1934	Mauntel Woods--Section A		50 10 m x 10 m quadrats
51	Potzger and Friesner 1940	14 forests in central Indiana		10 m x 10 m quadrats along east-west line
52	Robertson 1987	Boulder Slope Woods--mid-slope		27 0.04-ha plots along transects 100-150 m apart
53	Schmelz 1964	Beall Woods--upland (Stand 13)		Areal strip
53	Schmelz 1964	Davis Forestry Farm Woods (Stand 6)		Full tally using rectangular areas and strips
53	Schmelz 1964	Ross Biological Reserve Woods (Stand 7)		Full tally
54	Schmelz and Hodde 1970	James Bird Woods		Census of 5.5 ha
55	Spetich et al. 1996	Davis-Purdue Research Forest		30 0.1-ha plots located along a grid
55	Spetich et al. 1996	Hemmer Woods		30 0.1-ha plots located along a grid
55	Spetich et al. 1996	Pioneer Mothers	mesophytic	30 0.1-ha plots located along a grid
56	Stout 1944	Babcock Oak Opening		Ring counts in trees blown down in 1941
57	Sulser 1971	Hutcheson Memorial Forest--1969		25 10 m x 10 m plots along transects
58	Ward and Parker 1989	Davis-Purdue Research Forest--1986	transition to sugar maple	10 m x 10 m quadrats in 9 ha; 5 m x 5 m for canopy cover
59	Wing 1937	Oak openings in vicinity of Grass Lake		Observation of giant trees, distinct circles in soils [9]

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[1] Stand in late stages of succession to mixed mesophytic.

[2] Letter from Edmund Stiles to Greg Nowacki, October 22, 1992 suggests Hutcheson Memorial Forest falls into dry-mesic forest type.

[3] Survey conducted 1821-22.

[4] Sugar maple increasing in importance.

[5] Transition from oak-hickory to sugar maple-dominated.

[6] Forest includes 3 areas: (1) oak-hickory, (2) sugar maple-dominated, (3) elm, white ash, hickory, sugar maple.

[7] Some methods described in Rochow 1972.

[8] Includes forest types other than just oaks.

[9] Suspects circles 18 m in diameter are sites where former oaks modified soil from black to yellow.

Table 40.—*Density of live trees ≥10, ≥50, and ≥70 cm for mesic and wet-mesic oak old-growth study sites. For other minimum sizes, the density is listed under "≥X cm", with the minimum size for tallying trees given as "Min Diam X (cm)".*

			Live Tree Density				
Map Key	**Source/Date**	**Stand**	**≥10 cm (#/ha)**	**≥50 cm (#/ha)**	**≥70 cm (#/ha)**	**≥X cm (#/ha)**	**Min Diam X (cm)**
1	Abrams and Downs 1990	Sophia's Woods	405		15		
2	Boerner and Kooser 1991	Drew Woods	456[1]	45[1]	27[1]	914	2.5
3	Boggess and Geis 1965	Funk Forest Natural Area				332	7.6
4	Boggess and Geis 1967	Robert Allerton Park				554	7.6
5	Braun 1950	Shenandoah Valley--Berryville vicinity					
6	Bray 1960	Albion Oak Opening					
7	Brewer and Kitler 1989	Pioneer Cemetery Park		59[2]		64	38
7	Brewer and Kitler 1989	Presettlement Michigan bur oak openings				3-45	unspecified
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand A				}12-17[3]	20
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand B				}	
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand C				}	
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand D				}	
9	Buell 1957	Mettler's Woods [Hutcheson]					
10	Buell et al. 1954	Mettler's Woods [Hutcheson]					
11	Ebinger 1968	Sargents Woods	343				
12	Ebinger 1987	Presettlement oak forests in Illinois				[4]	
13	Ebinger and McClain 1991	Baber Woods Nature Preserve-1990					
14	Ebinger and Newman 1984	Embarass River--dry-mesic upland forest	243				
15	Ebinger and Parker 1969	Rocky Branch Nature Preserve	337				
16	Forman and Elfstrom 1975	Hutcheson Memorial Forest	270				
16	Forman and Elfstrom 1975	Maryknoll Farm East	238				
16	Forman and Elfstrom 1975	Maryknoll Farm West	443				
16	Forman and Elfstrom 1975	Reno Farm	270				
16	Forman and Elfstrom 1975	Ringoes Corso Woods	330				
16	Forman and Elfstrom 1975	Water Tower Woods	171				
16	Forman and Elfstrom 1975	Western Electric Woods	303				
16	Forman and Elfstrom 1975	Wohendorf-Perry Woods	285				
17	Fralish et al. 1991	Shawnee Hills--presettlement ridgetop	127[5]				
17	Fralish et al. 1991	Shawnee Hills--old-growth ridgetop					
18	Frei and Fairbrothers 1963	Hutcheson Memorial Forest					
19	Goebel and Hix 1996	Hawk Woods, Ketcham Woods, Strouds Run	365				
20	Hale 1996	10 oak stands in Minnesota	384[6]	94	4		
20	Hale 1996	Arrowpoint	488	75	0		
20	Hale 1996	Caledonia OG	250	63	0		
20	Hale 1996	Denmark	425	88	0		
20	Hale 1996	Evers	388	100	0		
20	Hale 1996	Hientz 25	500	125	13		

(Table 40 continued on next page)

(Table 40 continued)

			Live Tree Density				Min Diam
Map Key	Source/Date	Stand	≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X cm (#/ha)	X (cm)
20	Hale 1996	Leon 9	438	175	0		
20	Hale 1996	Melcher Ridge	350	88	13		
20	Hale 1996	Sheldon 27	388	50	0		
20	Hale 1996	White Water	338	113	0		
20	Hale 1996	Zimmerman	275	63	13		
21	Hammit and Barnes 1989	Radrick Forest--1968	602			1184 [7]	2.54
21	Hammit and Barnes 1989	Radrick Forest--1988	498			1192	2.54
22	Jackson and Petty 1971	Foley Woods	357				
23	Johnson and Bell 1975	3 streamside forests in Illinois					
24	Johnson et al. 1972	Bryan Nature Preserve		19 [8]		198	12.4
25	Lang and Forman 1978	Hutcheson Memorial Forest					
26	Laughlin 1947	Big Oak Tree State Park					
27	Leitner 1988d	Sanders Park Hardwoods	480	38			
28	Leitner 1989a	Blue Spring Oak Opening	124	8			
29	Leitner and Jackson 1981	Presettlement forests of unglaciated Illinois				176	[9]
30	Leopold et al. 1985	Davis-Purdue Research Forest	320				
31	Lindsey 1963	Beall Woods	284				
32	Lindsey et al. 1969	Donaldson's Woods/Spring Mill State Park	290				
32	Lindsey et al. 1969	James Bird Woods					
33	McCarthy et al. 1987	Hawk Woods--white oak	250				
33	McCarthy et al. 1987	Hawk Woods--oak-hickory	329				
34	McClain and Ebinger 1968	Baber Woods--1964	265				
35	McCoy 1939	Illinoian Till Plain--Forests Q-Y				303 [10]	15.2
36	McCune and Cottam 1985	Noe Woods--1956					
36	McCune and Cottam 1985	Noe Woods--1968					
36	McCune and Cottam 1985	Noe Woods--1983					
37	McCune et al. 1988	Hemmer Woods				779	4
38	Miceli et al. 1977	Big Grove--Brownfield Woods				484	6.4
39	Monk 1961a	Hutcheson Memorial Forest--upland				290	2.54
40	Monk 1961b	Hutcheson Memorial Forest--upland				294	2.54
41	Newman and Ebinger 1985	Baber Woods--1983	279				
42	Pallardy et al. 1991	Ashland Wildlife Area--mesic slope 1968				410	8.9
42	Pallardy et al. 1991	Ashland Wildlife Area--mesic slope 1982				363	8.9
43	Parker 1989	Central Hardwood Region--mesic uplands	161-427				
44	Parker and Leopold 1983	Davis-Purdue Research Forest--1976	320				
45	Parker and Leopold 1985	Davis-Purdue Research Forest--1926-1976					
46	Parker and Sherwood 1986	Davis-Purdue Research Forest--1985					

(Table 40 continued on next page)

(Table 40 continued)

			Live Tree Density				
Map Key	Source/Date	Stand	≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X cm (#/ha)	Min Diam X (cm)
47	Parker and Ward 1987	Davis-Purdue Research Forest--1976	338	52		144	20
48	Parker et al. 1985	Davis-Purdue Research Forest--1976	320				
49	Potzger and Chandler 1952	Gilbert Lubbe Woods		80		525	7.6
49	Potzger and Chandler 1952	John Burman Woods		85		500	7.6
49	Potzger and Chandler 1952	Fred Harting Woods		35		860	7.6
49	Potzger and Chandler 1952	Lemon Woods		5		965	7.6
50	Potzger and Friesner 1934	Mauntel Woods--Section A		29	6	1066	2.54
51	Potzger and Friesner 1940	14 forests in central Indiana		15 [11]		[12]	
52	Robertson 1987	Boulder Slope Woods--mid-slope				[13]	
53	Schmelz 1964	Beall Woods--upland (Stand 13)	284				
53	Schmelz 1964	Davis Forestry Farm Woods (Stand 6)	161				
53	Schmelz 1964	Ross Biological Reserve Woods (Stand 7)	338				
54	Schmelz and Hodde 1970	James Bird Woods	316	52	17		
55	Spetich et al. 1996	Davis-Purdue Research Forest				2300	2
55	Spetich et al. 1996	Hemmer Woods				1967	2
55	Spetich et al. 1996	Pioneer Mothers				5000	2
56	Stout 1944	Babcock Oak Opening					
57	Sulser 1971	Hutcheson Memorial Forest--1969	564			953	2.54
58	Ward and Parker 1989	Davis-Purdue Research Forest--1986					
59	Wing 1937	Oak openings in vicinity of Grass Lake					

[1] Values based on upland plots.

[2] Value for tree density >50 cm is actually for trees >50.8 cm.

[3] Range of values for all stands studied.

[4] Some indication of tree density for trees selected as witness trees can be estimated from average distance to witness trees: 9 m for white oak, 14 m for black oak.

[5] 107 trees/ha when dogwood witness trees are omitted.

[6] Averages of 10 stands that follow.

[7] Density of trees >25.4 cm is 137 trees/ha.

[8] Density >50.8 cm (not >50) based on white oak, white ash, American beech, sugar maple.

[9] Diameter unspecified--based on witness trees selected.

[10] Average density for the 9 forests.

[11] Density >50 cm may be average for both oak-hickory and maple-beech forest types.

[12] Tallies of trees for >15.2 cm given, but unclear what the area of sampling was.

[13] Tree density reported in the paper is the average for all sites, including uplands and the adjacent slough.

Table 41.—*Basal area of live trees ≥10, ≥50, and ≥70 cm for mesic and wet-mesic oak old-growth study sites. For other minimum sizes, the basal area is listed under "≥X cm", with the minimum size for tallying trees given as "Min Diam X (cm)".*

			Live Tree Basal Area (BA)				
Map Key	**Source/Date**	**Stand**	**≥10 cm (m^2/ha)**	**≥50 cm (m^2/ha)**	**≥70 cm (m^2/ha)**	**≥X cm (m^2/ha)**	**Min Diam X (cm)**
1	Abrams and Downs 1990	Sophia's Woods					
2	Boerner and Kooser 1991	Drew Woods				51.8 [1]	2.5
3	Boggess and Geis 1965	Funk Forest Natural Area				27.1	7.6
4	Boggess and Geis 1967	Robert Allerton Park				23.4	7.6
5	Braun 1950	Shenandoah Valley--Berryville vicinity					
6	Bray 1960	Albion Oak Opening					
7	Brewer and Kitler 1989	Pioneer Cemetery Park					
7	Brewer and Kitler 1989	Presettlement Michigan bur oak openings					
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand A				9.2	20
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand B				9.6	20
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand C				9.9	20
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand D				10.7	20
9	Buell 1957	Mettler's Woods [Hutcheson]					
10	Buell et al. 1954	Mettler's Woods [Hutcheson]					
11	Ebinger 1968	Sargents Woods	20.7				
12	Ebinger 1987	Presettlement oak forests in Illinois					
13	Ebinger and McClain 1991	Baber Woods Nature Preserve-1990					
14	Ebinger and Newman 1984	Embarass River--dry-mesic upland forest				23.4	
15	Ebinger and Parker 1969	Rocky Branch Nature Preserve	22.7				
16	Forman and Elfstrom 1975	Hutcheson Memorial Forest	0.72 [2]				
16	Forman and Elfstrom 1975	Maryknoll Farm East	0.60 [3]				
16	Forman and Elfstrom 1975	Maryknoll Farm West	0.75 [4]				
16	Forman and Elfstrom 1975	Reno Farm	0.69 [5]				
16	Forman and Elfstrom 1975	Ringoes Corso Woods	0.62 [6]				
16	Forman and Elfstrom 1975	Water Tower Woods	0.5 [7]				
16	Forman and Elfstrom 1975	Western Electric Woods	0.81 [8]				
16	Forman and Elfstrom 1975	Wohendorf-Perry Woods	0.84 [9]				
17	Fralish et al. 1991	Shawnee Hills--presettlement ridgetop	14.0 [10]				
17	Fralish et al. 1991	Shawnee Hills--old-growth ridgetop	20.2				
18	Frei and Fairbrothers 1963	Hutcheson Memorial Forest					
19	Goebel and Hix 1996	Hawk Woods, Ketcham Woods, Strouds Run	30.8				
20	Hale 1996	10 oak stands in Minnesota	32.0				
20	Hale 1996	Arrowpoint	34.2				
20	Hale 1996	Caledonia OG	19.3				
20	Hale 1996	Denmark	31.1				
20	Hale 1996	Evers	32.2				
20	Hale 1996	Hientz 25	40.0				

(Table 41 continued on next page)

(Table 41 continued)

			Live Tree Basal Area (BA)				
Map Key	Source/Date	Stand	≥10 cm (m^2/ha)	≥50 cm (m^2/ha)	≥70 cm (m^2/ha)	≥X cm (m^2/ha)	Min Diam X (cm)
20	Hale 1996	Leon 9	47.2				
20	Hale 1996	Melcher Ridge	32.9				
20	Hale 1996	Sheldon 27	23.0				
20	Hale 1996	White Water	32.9				
20	Hale 1996	Zimmerman	26.8				
21	Hammit and Barnes 1989	Radrick Forest--1968					
21	Hammit and Barnes 1989	Radrick Forest--1988					
22	Jackson and Petty 1971	Foley Woods	25.1				
23	Johnson and Bell 1975	3 streamside forests in Illinois					
24	Johnson et al. 1972	Bryan Nature Preserve				28.8	12.4
25	Lang and Forman 1978	Hutcheson Memorial Forest					
26	Laughlin 1947	Big Oak Tree State Park					
27	Leitner 1988d	Sanders Park Hardwoods	31.3				
28	Leitner 1989a	Blue Spring Oak Opening	11.8				
29	Leitner and Jackson 1981	Presettlement forests of unglaciated Illinois				21.3	witness
30	Leopold et al. 1985	Davis-Purdue Research Forest	31.0				
31	Lindsey 1963	Beall Woods	34.9				
32	Lindsey et al. 1969	Donaldson's Woods/Spring Mill State Park	29.5				
32	Lindsey et al. 1969	James Bird Woods					
33	McCarthy et al. 1987	Hawk Woods--white oak	25.5				
33	McCarthy et al. 1987	Hawk Woods--oak-hickory	41.0				
34	McClain and Ebinger 1968	Baber Woods--1964	24.1				
35	McCoy 1939	Illinoian Till Plain--Forests Q-Y					
36	McCune and Cottam 1985	Noe Woods--1956	27.1				
36	McCune and Cottam 1985	Noe Woods--1968	29.1				
36	McCune and Cottam 1985	Noe Woods--1983	28.2				
37	McCune et al. 1988	Hemmer Woods				26.2	4
38	Miceli et al. 1977	Big Grove--Brownfield Woods				31.5	7.6
39	Monk 1961a	Hutcheson Memorial Forest--upland					
40	Monk 1961b	Hutcheson Memorial Forest--upland				20.5	2.54
41	Newman and Ebinger 1985	Baber Woods--1983	26.6				
42	Pallardy et al. 1991	Ashland Wildlife Area--mesic slope 1968				28.5	8.9
42	Pallardy et al. 1991	Ashland Wildlife Area--mesic slope 1982				24.7	8.9
43	Parker 1989	Central Hardwood Region--mesic uplands	25.0-35.0				
44	Parker and Leopold 1983	Davis-Purdue Research Forest--1976	31.0				
45	Parker and Leopold 1985	Davis-Purdue Research Forest--1926-1976					
46	Parker and Sherwood 1986	Davis-Purdue Research Forest--1985					

(Table 41 continued on next page)

(Table 41 continued)

Map Key	Source/Date	Stand	Live Tree Basal Area (BA)				
			$\geq$10 cm (m^2/ha)	$\geq$50 cm (m^2/ha)	$\geq$70 cm (m^2/ha)	$\geq$X cm (m^2/ha)	Min Diam X (cm)
47	Parker and Ward 1987	Davis-Purdue Research Forest--1976					
48	Parker et al. 1985	Davis-Purdue Research Forest--1976	31.0				
49	Potzger and Chandler 1952	Gilbert Lubbe Woods					
49	Potzger and Chandler 1952	John Burman Woods					
49	Potzger and Chandler 1952	Fred Harting Woods					
49	Potzger and Chandler 1952	Lemon Woods					
50	Potzger and Friesner 1934	Mauntel Woods--Section A					
51	Potzger and Friesner 1940	14 forests in central Indiana					
52	Robertson 1987	Boulder Slope Woods--mid-slope				25.5	6.6
53	Schmelz 1964	Beall Woods--upland (Stand 13)	34.9				
53	Schmelz 1964	Davis Forestry Farm Woods (Stand 6)	23.6				
53	Schmelz 1964	Ross Biological Reserve Woods (Stand 7)	19.5				
54	Schmelz and Hodde 1970	James Bird Woods	28.9				
55	Spetich et al. 1996	Davis-Purdue Research Forest				32.1	2
55	Spetich et al. 1996	Hemmer Woods				25.1	2
55	Spetich et al. 1996	Pioneer Mothers				28.3	2
56	Stout 1944	Babcock Oak Opening					
57	Sulser 1971	Hutcheson Memorial Forest--1969				16.6	2.54
58	Ward and Parker 1989	Davis-Purdue Research Forest--1986					
59	Wing 1937	Oak openings in vicinity of Grass Lake					

[1] Value based on upland plots.

[2] Value for basal area seems low but is reported as follows: 2595 cm^2 per 4 transects of 10 m x 90 m.

[3] Value for basal area seems low but is reported as follows: 8075 cm^2 per 14 transects of 10 m x 90 m.

[4] Value for basal area seems low but is reported as follows: 2016 cm^2 per 3 transects of 10 m x 90 m.

[5] Value for basal area seems low but is reported as follows: 1858 cm^2 per 3 transects of 10 m x 90 m.

[6] Value for basal area seems low but is reported as follows: 1664 cm^2 per 3 transects of 10 m x 90 m.

[7] Value for basal area seems low but is reported as follows: 3581 cm^2 per 3 transects of 10 m x 90 m.

[8] Value for basal area seems low but is reported as follows: 2195 cm^2 per 3 transects of 10 m x 90 m.

[9] Value for basal area seems low but is reported as follows: 2279 cm^2 per 3 transects of 10 m x 90 m.

[10] Basal area is 13.4 m^2/ha when dogwood witness trees are omitted.

Table 42.—*Average and maximum tree age by species for mesic and wet-mesic oak old-growth study sites. Abbreviations for tree species are as follows: AmElm, American elm; BAsh, black ash; ChinkO, chinkapin oak; PignH, pignut hickory.*

			--------Average Tree Age (yr)------			----------------------------Maximum Tree Age (yr)----------------------------					
Map Key	Source/Date	Stand	White Oak	Bur Oak	Other	White Oak	Black Oak	Bur Oak	Chinkapin Oak	Shumard Oak	Other
1	Abrams and Downs 1990	Sophia's Woods				310	240				
2	Boerner and Kooser 1991	Drew Woods									
3	Boggess and Geis 1965	Funk Forest Natural Area									
4	Boggess and Geis 1967	Robert Allerton Park									
5	Braun 1950	Shenandoah Valley--Berryville vicinity									
6	Bray 1960	Albion Oak Opening						200+			
7	Brewer and Kitler 1989	Pioneer Cemetery Park						180+			
7	Brewer and Kitler 1989	Presettlement Michigan bur oak openings									
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand A						}440 [1]	}395 [1]	}480 [1]	BAsh-405 [1], AmElm-410 [1]
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand B						}	}	}	
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand C						}	}	}	
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand D						}	}	}	
9	Buell 1957	Mettler's Woods [Hutcheson]				323					
10	Buell et al. 1954	Mettler's Woods [Hutcheson]									
11	Ebinger 1968	Sargents Woods									
12	Ebinger 1987	Presettlement oak forests in Illinois									
13	Ebinger and McClain 1991	Baber Woods Nature Preserve-1990	148 [2]			313					
14	Ebinger and Newman 1984	Embarass River--dry-mesic upland forest									
15	Ebinger and Parker 1969	Rocky Branch Nature Preserve									
16	Forman and Elfstrom 1975	Hutcheson Memorial Forest									
16	Forman and Elfstrom 1975	Maryknoll Farm East									
16	Forman and Elfstrom 1975	Maryknoll Farm West									
16	Forman and Elfstrom 1975	Reno Farm									
16	Forman and Elfstrom 1975	Ringoes Corso Woods									
16	Forman and Elfstrom 1975	Water Tower Woods									
16	Forman and Elfstrom 1975	Western Electric Woods									
16	Forman and Elfstrom 1975	Wohendorf-Perry Woods									
17	Fralish et al. 1991	Shawnee Hills--presettlement ridgetop									
17	Fralish et al. 1991	Shawnee Hills--old-growth ridgetop									
18	Frei and Fairbrothers 1963	Hutcheson Memorial Forest				324 [3]					
19	Goebel and Hix 1996	Hawk Woods, Ketcham Woods, Strouds Run									
20	Hale 1996	10 oak stands in Minnesota									
20	Hale 1996	Arrowpoint			108 [4]						
20	Hale 1996	Caledonia OG			135 [4]						
20	Hale 1996	Denmark			81 [4]						
20	Hale 1996	Evers			130 [4]						
20	Hale 1996	Hientz 25			98 [4]						

(Table 42 continued on next page)

(Table 42 continued)

Map Key	Source/Date	Stand	Average Tree Age (yr)			Maximum Tree Age (yr)					
			White Oak	Bur Oak	Other	White Oak	Black Oak	Bur Oak	Chinkapin Oak	Shumard Oak	Other
20	Hale 1996	Leon 9			139[4]						
20	Hale 1996	Melcher Ridge			164[4]						
20	Hale 1996	Sheldon 27			128[4]						
20	Hale 1996	White Water			86[4]						
20	Hale 1996	Zimmerman			129[4]						
21	Hammit and Barnes 1989	Radrick Forest--1968					140				
21	Hammit and Barnes 1989	Radrick Forest--1988									
22	Jackson and Petty 1971	Foley Woods									PignH-153
23	Johnson and Bell 1975	3 streamside forests in Illinois				~300					
24	Johnson et al. 1972	Bryan Nature Preserve									
25	Lang and Forman 1978	Hutcheson Memorial Forest									
26	Laughlin 1947	Big Oak Tree State Park									
27	Leitner 1988d	Sanders Park Hardwoods									
28	Leitner 1989a	Blue Spring Oak Opening									
29	Leitner and Jackson 1981	Presettlement forests of unglaciated Illinois									
30	Leopold et al. 1985	Davis-Purdue Research Forest									
31	Lindsey 1963	Beall Woods									
32	Lindsey et al. 1969	Donaldson's Woods/Spring Mill State Park									
32	Lindsey et al. 1969	James Bird Woods									
33	McCarthy et al. 1987	Hawk Woods--white oak									
33	McCarthy et al. 1987	Hawk Woods--oak-hickory									
34	McClain and Ebinger 1968	Baber Woods--1964									
35	McCoy 1939	Illinoian Till Plain--Forests Q-Y									
36	McCune and Cottam 1985	Noe Woods--1956									
36	McCune and Cottam 1985	Noe Woods--1968									
36	McCune and Cottam 1985	Noe Woods--1983									
37	McCune et al. 1988	Hemmer Woods									
38	Miceli et al. 1977	Big Grove--Brownfield Woods		400+	ChinkO-400+						
39	Monk 1961a	Hutcheson Memorial Forest--upland									Oak?--200-225
40	Monk 1961b	Hutcheson Memorial Forest--upland									
41	Newman and Ebinger 1985	Baber Woods--1983									
42	Pallardy et al. 1991	Ashland Wildlife Area--mesic slope 1968									
42	Pallardy et al. 1991	Ashland Wildlife Area--mesic slope 1982									
43	Parker 1989	Central Hardwood Region--mesic uplands									190-375[5]
44	Parker and Leopold 1983	Davis-Purdue Research Forest--1976									
45	Parker and Leopold 1985	Davis-Purdue Research Forest--1926-1976									
46	Parker and Sherwood 1986	Davis-Purdue Research Forest--1985									

(Table 42 continued on next page)

(Table 42 continued)

Map			--------Average Tree Age (yr)------			-----------------------------Maximum Tree Age (yr)------------------------------					
Key	Source/Date	Stand	White Oak	Bur Oak	Other	White Oak	Black Oak	Bur Oak	Chinkapin Oak	Shumard Oak	Other
47	Parker and Ward 1987	Davis-Purdue Research Forest--1976									
48	Parker et al. 1985	Davis-Purdue Research Forest--1976			Oak-136			350			
49	Potzger and Chandler 1952	Gilbert Lubbe Woods									
49	Potzger and Chandler 1952	John Burman Woods									
49	Potzger and Chandler 1952	Fred Harting Woods									
49	Potzger and Chandler 1952	Lemon Woods									
50	Potzger and Friesner 1934	Mauntel Woods--Section A									
51	Potzger and Friesner 1940	14 forests in central Indiana									
52	Robertson 1987	Boulder Slope Woods--mid-slope									
53	Schmelz 1964	Beall Woods--upland (Stand 13)									
53	Schmelz 1964	Davis Forestry Farm Woods (Stand 6)									
53	Schmelz 1964	Ross Biological Reserve Woods (Stand 7)									
54	Schmelz and Hodde 1970	James Bird Woods									
55	Spetich et al. 1996	Davis-Purdue Research Forest			187						
55	Spetich et al. 1996	Hemmer Woods			167						
55	Spetich et al. 1996	Pioneer Mothers			194						
56	Stout 1944	Babcock Oak Opening		200							
57	Sulser 1971	Hutcheson Memorial Forest--1969									
58	Ward and Parker 1989	Davis-Purdue Research Forest--1986									
59	Wing 1937	Oak openings in vicinity of Grass Lake	150 +								

[1] Maximum tree ages for all stands studied.

[2] Average age based on 5 white oaks that had died recently.

[3] Rings counted in tree that fell during 1950 storm; species is unspecified but Buell (1957) lists the tree as a white oak.

[4] Stand age is average of 5 oldest trees of 10 cored in the stand.

[5] Maximum age of overstory mortality (including species other than oak-hickory).

Table 43.—*Maximum tree diameter by species, and the percentage of the tree canopy in gaps for mesic and wet-mesic oak old-growth study sites. Abbreviations for tree species are as follows: BAsh, black ash; ChestO, chestnut oak; ChinkO, chinkapin oak; Hi, hickory; RO, northern red oak; ShagBHick, shagbark hickory; ShellHick, shellbark hickory; SM, sugar maple; WAsh, white ash; YP, yellow-poplar.*

Map Key	Source/Date	Stand	----Maximum Tree Diameter (cm)---- White Oak	Black Oak	Bur Oak	Shumard Oak	Other	Canopy Gaps (%)
1	Abrams and Downs 1990	Sophia's Woods	96	55			Beech-70	
2	Boerner and Kooser 1991	Drew Woods	120		120			
3	Boggess and Geis 1965	Funk Forest Natural Area			150		SM-84	
4	Boggess and Geis 1967	Robert Allerton Park	94+					
5	Braun 1950	Shenandoah Valley--Berryville vicinity	91+					
6	Bray 1960	Albion Oak Opening						
7	Brewer and Kitler 1989	Pioneer Cemetery Park	88	94	88			
7	Brewer and Kitler 1989	Presettlement Michigan bur oak openings			25			
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand A			160	168	BAsh-150	
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand B						
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand C						
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand D						
9	Buell 1957	Mettler's Woods [Hutcheson]						
10	Buell et al. 1954	Mettler's Woods [Hutcheson]	130					
11	Ebinger 1968	Sargents Woods	109	94+				
12	Ebinger 1987	Presettlement oak forests in Illinois	96+	96+			RO-96+	
13	Ebinger and McClain 1991	Baber Woods Nature Preserve-1990	102					
14	Ebinger and Newman 1984	Embarass River--dry-mesic upland forest						
15	Ebinger and Parker 1969	Rocky Branch Nature Preserve		86				
16	Forman and Elfstrom 1975	Hutcheson Memorial Forest						
16	Forman and Elfstrom 1975	Maryknoll Farm East						
16	Forman and Elfstrom 1975	Maryknoll Farm West						
16	Forman and Elfstrom 1975	Reno Farm						
16	Forman and Elfstrom 1975	Ringoes Corso Woods						
16	Forman and Elfstrom 1975	Water Tower Woods						
16	Forman and Elfstrom 1975	Western Electric Woods						
16	Forman and Elfstrom 1975	Wohendorf-Perry Woods						
17	Fralish et al. 1991	Shawnee Hills--presettlement ridgetop	112					
17	Fralish et al. 1991	Shawnee Hills--old-growth ridgetop						
18	Frei and Fairbrothers 1963	Hutcheson Memorial Forest	102					
19	Goebel and Hix 1996	Hawk Woods, Ketcham Woods, Strouds Run					70+	
20	Hale 1996	10 oak stands in Minnesota						
20	Hale 1996	Arrowpoint						
20	Hale 1996	Caledonia OG						
20	Hale 1996	Denmark						
20	Hale 1996	Evers						
20	Hale 1996	Hientz 25						

(Table 43 continued on next page)

(Table 43 continued)

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm)					Canopy Gaps (%)
			White Oak	Black Oak	Bur Oak	Shumard Oak	Other	
20	Hale 1996	Leon 9						
20	Hale 1996	Melcher Ridge						
20	Hale 1996	Sheldon 27						
20	Hale 1996	White Water						
20	Hale 1996	Zimmerman						
21	Hammit and Barnes 1989	Radrick Forest--1968						
21	Hammit and Barnes 1989	Radrick Forest--1988						
22	Jackson and Petty 1971	Foley Woods	73		138		ChinkO-107; RO-97	3.8 [1]
23	Johnson and Bell 1975	3 streamside forests in Illinois	65+ [2]				Oak-60+ [2]	
24	Johnson et al. 1972	Bryan Nature Preserve						
25	Lang and Forman 1978	Hutcheson Memorial Forest						
26	Laughlin 1947	Big Oak Tree State Park			196		ChestO-119	
27	Leitner 1988d	Sanders Park Hardwoods			75+			
28	Leitner 1989a	Blue Spring Oak Opening						
29	Leitner and Jackson 1981	Presettlement forests of unglaciated Illinois	127	127			Hi-91	
30	Leopold et al. 1985	Davis-Purdue Research Forest						
31	Lindsey 1963	Beall Woods	102	97	158			
32	Lindsey et al. 1969	Donaldson's Woods/Spring Mill State Park	122				YP-132	
32	Lindsey et al. 1969	James Bird Woods	129				YP-103	
33	McCarthy et al. 1987	Hawk Woods--white oak					Oak?-85	
33	McCarthy et al. 1987	Hawk Woods--oak-hickory					Oak?-70+	
34	McClain and Ebinger 1968	Baber Woods--1964	117					
35	McCoy 1939	Illinoian Till Plain--Forests Q-Y	64+	64+				
36	McCune and Cottam 1985	Noe Woods--1956	62	68				
36	McCune and Cottam 1985	Noe Woods--1968	68	72				
36	McCune and Cottam 1985	Noe Woods--1983	77	83				
37	McCune et al. 1988	Hemmer Woods	119	82			RO-68, ShagBHick-68	
38	Miceli et al. 1977	Big Grove--Brownfield Woods					91-152 [3]	
39	Monk 1961a	Hutcheson Memorial Forest--upland					Oak?-102	
40	Monk 1961b	Hutcheson Memorial Forest--upland						7
41	Newman and Ebinger 1985	Baber Woods--1983						
42	Pallardy et al. 1991	Ashland Wildlife Area--mesic slope 1968						
42	Pallardy et al. 1991	Ashland Wildlife Area--mesic slope 1982						
43	Parker 1989	Central Hardwood Region--mesic uplands						7-8
44	Parker and Leopold 1983	Davis-Purdue Research Forest--1976						
45	Parker and Leopold 1985	Davis-Purdue Research Forest--1926-1976						
46	Parker and Sherwood 1986	Davis-Purdue Research Forest--1985	101		82		RO-85, WAsh-85	

(Table 43 continued on next page)

(Table 43 continued)

Map			Maximum Tree Diameter (cm)					Canopy
			White	Black	Bur	Shumard		Gaps
Key	Source/Date	Stand	Oak	Oak	Oak	Oak	Other	(%)
47	Parker and Ward 1987	Davis-Purdue Research Forest--1976						
48	Parker et al. 1985	Davis-Purdue Research Forest--1976	110+		140+		RO-90+	
49	Potzger and Chandler 1952	Gilbert Lubbe Woods	137					
49	Potzger and Chandler 1952	John Burman Woods						
49	Potzger and Chandler 1952	Fred Harting Woods						
49	Potzger and Chandler 1952	Lemon Woods						
50	Potzger and Friesner 1934	Mauntel Woods--Section A	81 [4]	81 [4]			ShellH-53.3	
51	Potzger and Friesner 1940	14 forests in central Indiana						
52	Robertson 1987	Boulder Slope Woods--mid-slope						
53	Schmelz 1964	Beall Woods--upland (Stand 13)						
53	Schmelz 1964	Davis Forestry Farm Woods (Stand 6)						
53	Schmelz 1964	Ross Biological Reserve Woods (Stand 7)						
54	Schmelz and Hodde 1970	James Bird Woods	129	96				
55	Spetich et al. 1996	Davis-Purdue Research Forest					126	
55	Spetich et al. 1996	Hemmer Woods					104	
55	Spetich et al. 1996	Pioneer Mothers					130	
56	Stout 1944	Babcock Oak Opening						
57	Sulser 1971	Hutcheson Memorial Forest--1969						0.7
58	Ward and Parker 1989	Davis-Purdue Research Forest--1986						9
59	Wing 1937	Oak openings in vicinity of Grass Lake						

[1] Reported as 96.2% cover along transect through plot.

[2] White oak size from Allerton.

[3] Diameters for oaks and several other species.

[4] Small diameters may indicate immature forests of central Indiana.

Table 44.—*Density, basal area, volume, and minimum diameter measured for standing dead trees (snags) on mesic and wet-mesic oak old-growth study sites.*

Map Key	Source/Date	Stand	Standing Dead Trees (Snags)			
			Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Snag Volume (m^3/ha)	Min Snag Diam (cm)
1	Abrams and Downs 1990	Sophia's Woods				
2	Boerner and Kooser 1991	Drew Woods	0.92[1]	3.0[1]		40
3	Boggess and Geis 1965	Funk Forest Natural Area	37[2]	4.9[3]		6.6
4	Boggess and Geis 1967	Robert Allerton Park				
5	Braun 1950	Shenandoah Valley--Berryville vicinity				
6	Bray 1960	Albion Oak Opening				
7	Brewer and Kitler 1989	Pioneer Cemetery Park				
7	Brewer and Kitler 1989	Presettlement Michigan bur oak openings				
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand A				
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand B				
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand C				
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand D				
9	Buell 1957	Mettler's Woods [Hutcheson]				
10	Buell et al. 1954	Mettler's Woods [Hutcheson]				
11	Ebinger 1968	Sargents Woods	22[4]	1.3[4]		10
12	Ebinger 1987	Presettlement oak forests in Illinois				
13	Ebinger and McClain 1991	Baber Woods Nature Preserve-1990				
14	Ebinger and Newman 1984	Embarass River--dry-mesic upland forest	10.1[5]			10
15	Ebinger and Parker 1969	Rocky Branch Nature Preserve	21[4]	0.7[4]		10
16	Forman and Elfstrom 1975	Hutcheson Memorial Forest				
16	Forman and Elfstrom 1975	Maryknoll Farm East				
16	Forman and Elfstrom 1975	Maryknoll Farm West				
16	Forman and Elfstrom 1975	Reno Farm				
16	Forman and Elfstrom 1975	Ringoes Corso Woods				
16	Forman and Elfstrom 1975	Water Tower Woods				
16	Forman and Elfstrom 1975	Western Electric Woods				
16	Forman and Elfstrom 1975	Wohendorf-Perry Woods				
17	Fralish et al. 1991	Shawnee Hills--presettlement ridgetop				
17	Fralish et al. 1991	Shawnee Hills--old-growth ridgetop				
18	Frei and Fairbrothers 1963	Hutcheson Memorial Forest				
19	Goebel and Hix 1996	Hawk Woods, Ketcham Woods, Strouds Run	40	2.0	18.5	10
20	Hale 1996	10 oak stands in Minnesota	33		26.6	10
20	Hale 1996	Arrowpoint	13		13.5	10
20	Hale 1996	Caledonia OG	63		74.8	10
20	Hale 1996	Denmark	25		9.1	10
20	Hale 1996	Evers	25		53.6	10
20	Hale 1996	Hientz 25	38		35.8	10

(Table 44 continued on next page)

(Table 44 continued)

Map Key	Source/Date	Stand	Standing Dead Trees (Snags) Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Snag Volume (m^3/ha)	Min Snag Diam (cm)
20	Hale 1996	Leon 9	50		37.8	10
20	Hale 1996	Melcher Ridge	13		1.8	10
20	Hale 1996	Sheldon 27	13		4.0	10
20	Hale 1996	White Water	88		35.4	10
20	Hale 1996	Zimmerman	0		0	10
21	Hammit and Barnes 1989	Radrick Forest--1968				
21	Hammit and Barnes 1989	Radrick Forest--1988				
22	Jackson and Petty 1971	Foley Woods	21	1.8		10
23	Johnson and Bell 1975	3 streamside forests in Illinois				
24	Johnson et al. 1972	Bryan Nature Preserve				
25	Lang and Forman 1978	Hutcheson Memorial Forest				
26	Laughlin 1947	Big Oak Tree State Park				
27	Leitner 1988d	Sanders Park Hardwoods	22	3.2		10
28	Leitner 1989a	Blue Spring Oak Opening	20	2.0		10
29	Leitner and Jackson 1981	Presettlement forests of unglaciated Illinois				
30	Leopold et al. 1985	Davis-Purdue Research Forest				
31	Lindsey 1963	Beall Woods				
32	Lindsey et al. 1969	Donaldson's Woods/Spring Mill State Park				
32	Lindsey et al. 1969	James Bird Woods				
33	McCarthy et al. 1987	Hawk Woods--white oak				
33	McCarthy et al. 1987	Hawk Woods--oak-hickory				
34	McClain and Ebinger 1968	Baber Woods--1964	23 [4]	1.5 [4]		10
35	McCoy 1939	Illinoian Till Plain--Forests Q-Y				
36	McCune and Cottam 1985	Noe Woods--1956				
36	McCune and Cottam 1985	Noe Woods--1968				
36	McCune and Cottam 1985	Noe Woods--1983				
37	McCune et al. 1988	Hemmer Woods	33 [4]	6.8 [4]		20
38	Miceli et al: 1977	Big Grove--Brownfield Woods				
39	Monk 1961a	Hutcheson Memorial Forest--upland				
40	Monk 1961b	Hutcheson Memorial Forest--upland				
41	Newman and Ebinger 1985	Baber Woods--1983				
42	Pallardy et al. 1991	Ashland Wildlife Area--mesic slope 1968				
42	Pallardy et al. 1991	Ashland Wildlife Area--mesic slope 1982				
43	Parker 1989	Central Hardwood Region--mesic uplands	19-44			10
44	Parker and Leopold 1983	Davis-Purdue Research Forest--1976				
45	Parker and Leopold 1985	Davis-Purdue Research Forest--1926-1976	3 [6]			10
46	Parker and Sherwood 1986	Davis-Purdue Research Forest--1985				

(Table 44 continued on next page)

(Table 44 continued)

Map Key	Source/Date	Stand	Standing Dead Trees (Snags) Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Snag Volume (m^3/ha)	Min Snag Diam (cm)
47	Parker and Ward 1987	Davis-Purdue Research Forest--1976				
48	Parker et al. 1985	Davis-Purdue Research Forest--1976	78 [7]			10
49	Potzger and Chandler 1952	Gilbert Lubbe Woods				
49	Potzger and Chandler 1952	John Burman Woods				
49	Potzger and Chandler 1952	Fred Harting Woods				
49	Potzger and Chandler 1952	Lemon Woods				
50	Potzger and Friesner 1934	Mauntel Woods--Section A				
51	Potzger and Friesner 1940	14 forests in central Indiana				
52	Robertson 1987	Boulder Slope Woods--mid-slope				
53	Schmelz 1964	Beall Woods--upland (Stand 13)				
53	Schmelz 1964	Davis Forestry Farm Woods (Stand 6)				
53	Schmelz 1964	Ross Biological Reserve Woods (Stand 7)				
54	Schmelz and Hodde 1970	James Bird Woods				
55	Spetich et al. 1996	Davis-Purdue Research Forest	115 [8]			2
55	Spetich et al. 1996	Hemmer Woods	168 [9]			2
55	Spetich et al. 1996	Pioneer Mothers	109 [10]			2
56	Stout 1944	Babcock Oak Opening				
57	Sulser 1971	Hutcheson Memorial Forest--1969				
58	Ward and Parker 1989	Davis-Purdue Research Forest--1986				
59	Wing 1937	Oak openings in vicinity of Grass Lake				

[1] Values based on upland plots.

[2] Combined snag and log density = 37.3/ha.

[3] Basal area for both snags and logs.

[4] Values for snag density and basal area reported here include downed logs (i.e., all dead trees).

[5] Most mortality was large white and black oaks.

[6] Average mortality since 1976 in stems per ha (per year??); American elm accounted for 30% of mortality.

[7] Snag density is total number of trees >10 cm living in 1926 that are dead in 1976 (this doesn't include trees that grew to >10 cm >1926 but subsequently died); snag density of dominant trees was 7 trees/ha over 50 years.

[8] Density of cavity trees was 83/ha.

[9] Density of cavity trees was 107/ha.

[10] Density of cavity trees was 109/ha.

Table 45.—*Density, volume, and minimum diameter measured for fallen dead trees (logs) for mesic and wet-mesic oak old-growth study sites.*

			Fallen Dead Trees (Logs)		
Map Key	**Source/Date**	**Stand**	**Density of Logs (#/ha)**	**Volume of Logs (m^3/ha)**	**Min Diam Logs (cm)**
1	Abrams and Downs 1990	Sophia's Woods			
2	Boerner and Kooser 1991	Drew Woods	0.31	[1]	40
3	Boggess and Geis 1965	Funk Forest Natural Area	[2]		6.6
4	Boggess and Geis 1967	Robert Allerton Park			
5	Braun 1950	Shenandoah Valley--Berryville vicinity			
6	Bray 1960	Albion Oak Opening			
7	Brewer and Kitler 1989	Pioneer Cemetery Park			
7	Brewer and Kitler 1989	Presettlement Michigan bur oak openings			
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand A		~	
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand B			
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand C			
8	Bryant et al. 1980	Inner Bluegrass Plateau--Stand D			
9	Buell 1957	Mettler's Woods [Hutcheson]			
10	Buell et al. 1954	Mettler's Woods [Hutcheson]			
11	Ebinger 1968	Sargents Woods	[3]		10
12	Ebinger 1987	Presettlement oak forests in Illinois			
13	Ebinger and McClain 1991	Baber Woods Nature Preserve-1990			
14	Ebinger and Newman 1984	Embarass River--dry-mesic upland forest			
15	Ebinger and Parker 1969	Rocky Branch Nature Preserve	[3]		10
16	Forman and Elfstrom 1975	Hutcheson Memorial Forest			
16	Forman and Elfstrom 1975	Maryknoll Farm East			
16	Forman and Elfstrom 1975	Maryknoll Farm West			
16	Forman and Elfstrom 1975	Reno Farm			
16	Forman and Elfstrom 1975	Ringoes Corso Woods			
16	Forman and Elfstrom 1975	Water Tower Woods			
16	Forman and Elfstrom 1975	Western Electric Woods			
16	Forman and Elfstrom 1975	Wohendorf-Perry Woods			
17	Fralish et al. 1991	Shawnee Hills--presettlement ridgetop			
17	Fralish et al. 1991	Shawnee Hills--old-growth ridgetop			
18	Frei and Fairbrothers 1963	Hutcheson Memorial Forest			
19	Goebel and Hix 1996	Hawk Woods, Ketcham Woods, Strouds Run	125	29.8	10
20	Hale 1996	10 oak stands in Minnesota	388	47.9 [4]	10
20	Hale 1996	Arrowpoint	513	54.5 [5]	10
20	Hale 1996	Caledonia OG	438	68.4 [6]	10
20	Hale 1996	Denmark	600	60.1 [7]	10
20	Hale 1996	Evers	313	57.5 [8]	10
20	Hale 1996	Hientz 25	325	50.6 [9]	10

(Table 45 continued on next page)

(Table 45 continued)

Map Key	Source/Date	Stand	Fallen Dead Trees (Logs) Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)
20	Hale 1996	Leon 9	263	28.9 [10]	10
20	Hale 1996	Melcher Ridge	288	32.6 [11]	10
20	Hale 1996	Sheldon 27	363	49.8 [12]	10
20	Hale 1996	White Water	263	20.8 [13]	10
20	Hale 1996	Zimmerman	513	56.1 [14]	10
21	Hammit and Barnes 1989	Radrick Forest--1968			
21	Hammit and Barnes 1989	Radrick Forest--1988			
22	Jackson and Petty 1971	Foley Woods			
23	Johnson and Bell 1975	3 streamside forests in Illinois			
24	Johnson et al. 1972	Bryan Nature Preserve			
25	Lang and Forman 1978	Hutcheson Memorial Forest	283 [15]		10
26	Laughlin 1947	Big Oak Tree State Park			
27	Leitner 1988d	Sanders Park Hardwoods	36	[16]	30
28	Leitner 1989a	Blue Spring Oak Opening	2	[17]	30
29	Leitner and Jackson 1981	Presettlement forests of unglaciated Illinois			
30	Leopold et al. 1985	Davis-Purdue Research Forest			
31	Lindsey 1963	Beall Woods			
32	Lindsey et al. 1969	Donaldson's Woods/Spring Mill State Park			
32	Lindsey et al. 1969	James Bird Woods			
33	McCarthy et al. 1987	Hawk Woods--white oak			
33	McCarthy et al. 1987	Hawk Woods--oak-hickory			
34	McClain and Ebinger 1968	Baber Woods--1964	[3]		10
35	McCoy 1939	Illinoian Till Plain--Forests Q-Y			
36	McCune and Cottam 1985	Noe Woods--1956			
36	McCune and Cottam 1985	Noe Woods--1968			
36	McCune and Cottam 1985	Noe Woods--1983			
37	McCune et al. 1988	Hemmer Woods	[3]		20
38	Miceli et al. 1977	Big Grove--Brownfield Woods			
39	Monk 1961a	Hutcheson Memorial Forest--upland			
40	Monk 1961b	Hutcheson Memorial Forest--upland			
41	Newman and Ebinger 1985	Baber Woods--1983			
42	Pallardy et al. 1991	Ashland Wildlife Area--mesic slope 1968			
42	Pallardy et al. 1991	Ashland Wildlife Area--mesic slope 1982			
43	Parker 1989	Central Hardwood Region--mesic uplands			
44	Parker and Leopold 1983	Davis-Purdue Research Forest--1976			
45	Parker and Leopold 1985	Davis-Purdue Research Forest--1926-1976	[18]		
46	Parker and Sherwood 1986	Davis-Purdue Research Forest--1985			

(Table 45 continued on next page)

(Table 45 continued)

Map Key	Source/Date	Stand	Fallen Dead Trees (Logs) Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)
47	Parker and Ward 1987	Davis-Purdue Research Forest--1976			
48	Parker et al. 1985	Davis-Purdue Research Forest--1976	[19]		
49	Potzger and Chandler 1952	Gilbert Lubbe Woods			
49	Potzger and Chandler 1952	John Burman Woods			
49	Potzger and Chandler 1952	Fred Harting Woods			
49	Potzger and Chandler 1952	Lemon Woods			
50	Potzger and Friesner 1934	Mauntel Woods--Section A			
51	Potzger and Friesner 1940	14 forests in central Indiana			
52	Robertson 1987	Boulder Slope Woods--mid-slope			
53	Schmelz 1964	Beall Woods--upland (Stand 13)			
53	Schmelz 1964	Davis Forestry Farm Woods (Stand 6)			
53	Schmelz 1964	Ross Biological Reserve Woods (Stand 7)			
54	Schmelz and Hodde 1970	James Bird Woods			
55	Spetich et al. 1996	Davis-Purdue Research Forest			
55	Spetich et al. 1996	Hemmer Woods		64.9	10
55	Spetich et al. 1996	Pioneer Mothers		68.2	10
56	Stout 1944	Babcock Oak Opening			
57	Sulser 1971	Hutcheson Memorial Forest--1969			
58	Ward and Parker 1989	Davis-Purdue Research Forest--1986			
59	Wing 1937	Oak openings in vicinity of Grass Lake			

[1] Basal area of logs (entire site) is 1.1 m^2/ha.

[2] Combined snag and log density = 37/ha.

[3] Values reported for snag density and basal area include downed logs (i.e., all dead trees).

[4] When volume is adjusted for log hollowness, value is 40.6.

[5] When volume is adjusted for log hollowness, value is 48.1.

[6] When volume is adjusted for log hollowness, value is 55.9.

[7] When volume is adjusted for log hollowness, value is 56.8.

[8] When volume is adjusted for log hollowness, value is 48.3.

[9] When volume is adjusted for log hollowness, value is 34.

[10] When volume is adjusted for log hollowness, value is 26.5.

[11] When volume is adjusted for log hollowness, value is 22.5.

[12] When volume is adjusted for log hollowness, value is 45.3.

[13] When volume is adjusted for log hollowness, value is 19.6.

[14] When volume is adjusted for log hollowness, value is 48.9.

[15] Range of density of logs: 150-425/ha.

[16] Basal area of logs is 5.3 m^2/ha.

[17] Basal area of logs is 0.29 m^2/ha.

[18] See Table 8, Endnote 6.

[19] See Table 8, Endnote 7.

Table 46.—*Summary of attributes for old-growth mesic and wet-mesic northern oak stands (from Tables 37 through 45).*

Attribute	Range	References (Map Key)
Live Tree Density (#/ha)		
- Trees ≥ 2.5 cm d.b.h.	290 - 1192	2, 21, 39, 40, 50, 57
- Trees ≥ 7.6 cm d.b.h.	332 - 965	3, 4
- Trees ≥ 10 cm d.b.h.	124 - 602	1, 2, 11, 14, 15, 16, 17, 19, 20, 33, 21, 22, 27, 28, 30, 31, 32, 34, 41, 44, 47, 48, 53, 54, 57
- Trees ≥ 50 cm d.b.h.	5 - 175	2, 7, 20, 24, 27, 28, 47, 49, 50, 51, 54
- Trees ≥ 70 cm d.b.h.	0 - 26.8	1, 2, 20, 50, 54
- Not as specified above		8, 12, 29, 35, 37, 38, 42, 55
Live Tree Basal Area (m^2/ha)		
- Trees ≥ 2.5 cm d.b.h.	16.6 - 51.8	2, 20, 57
- Trees ≥ 7.6 cm d.b.h.	23.4 - 31.5	3, 4
- Trees ≥ 10 cm d.b.h.	0.5 - 47.2	11, 15, 16, 17, 19, 20, 22, 27, 28, 30, 31, 32, 33, 34, 36, 41, 43, 44, 48, 53, 54
- Not as specified above		8, 14, 24, 29, 37, 42, 52, 55
Tree or Stand Age (yr)		
Average Age by Species		
- White Oak	148 - 150	13, 59
- Black Oak		
- Bur Oak	200 - >400	38, 56
- Other		20, 38, 48, 55
Maximum Age by Species		
- White Oak	300 - 324	1, 9, 13, 18, 23
- Black Oak	140 - 240	1, 21
- Bur Oak	180 - 440	6, 7, 8, 48
- Chestnut Oak	395	8
- Shumard Oak	480	8
- Other		8, 22, 39, 43

(Table 46 continued on next page)

(Table 46 continued)

Attribute	Range	References (Map Key)
Maximum Tree Diameter at Breast Height by Species (cm)		
- White Oak	62 - 137	1, 2, 4, 5, 7, 10, 11, 12, 13, 17, 18, 22, 23, 29, 31, 32, 34, 35, 35, 37, 46, 48, 49, 50, 54
- Black Oak	55 - 127	1, 7, 11, 12, 15, 29, 31, 35, 36, 37, 50, 54
- Bur Oak	25 - 196	2, 3, 7, 8, 22, 26, 27, 31, 46, 48
- Shumard Oak	168	8
- Other		1, 3, 8, 12, 19, 22, 23, 26, 29, 32, 33, 37, 38, 39, 46, 48, 50 55
Canopy Gaps (%)	0.7 - 9	22, 40, 43, 57, 58
Standing Dead Trees (Snags)		
Snag Density (#/ha)		
- Snags ≥ 2 cm d.b.h.	109 - 168	55
- Snags ≥ 10 cm d.b.h.	0 - 88	11, 14, 15, 19, 20, 22, 27, 28, 34, 43, 45, 48
- Not as specified above		2, 3, 37
Snag Basal Area (m^2/ha)		
- Snags ≥ 10 cm d.b.h.	0.7 - 3.2	11, 15, 19, 22, 27, 28, 34
- Not as specified above		2, 3, 37
Snag Volume (m^3/ha)		
- Snags ≥ 10 cm d.b.h.	0 - 74.8	19, 20
Fallen Dead Trees (Logs)		
Density of Logs (#/ha)		
- Logs ≥ 10 cm d.b.h.	125 - 600	10, 11, 15, 19, 20, 25, 34
- Not as specified above		2, 3, 27, 28, 37, 45, 48
Volume of Logs (m^3/ha)		
- Logs ≥ 10 cm d.b.h.	20.8 - 68.4	19, 20, 55
- Not as specified above		2, 8, 27, 28

HARDWOOD WETLAND FORESTS

COMMUNITY COMPOSITION

Forest cover types

The following Society of American Foresters (SAF) forest cover types (Eyre 1980) are included in the hardwood wetland forest type group:

39 - black ash-American elm-red maple
65 - pin oak-sweetgum
108 - red maple

The following Combined Data Systems (CDS) forest cover types for the USDA Forest Service Eastern Region (USDA 1974) are included in the hardwood wetland forest type group:

71 - black ash/American elm/red maple
76 - red maple (wet site)
79 - mixed lowland hardwoods

Species Composition

Species composition varies greatly among forests. Dominant trees include red maple (*Acer rubrum* L.), black ash (*Fraxinus nigra* Marsh.), green ash (*F. pennsylvanica* Marsh.), elms (*Ulmus* L.), sweetgum (*Liquidambar styraciflua* L.), pin oak (*Quercus palustris* Muenchh.), and blackgum (*Nyssa sylvatica* Marsh.).

Common associates vary by region. In the northern States, common associates are: balsam poplar (*Populus balsamifera* L.), yellow birch (*Betula alleghaniensis* Britton), and paper birch (*B. papyrifera* Marsh.). In the central States, common associates are silver maple (*A. saccharum* L.), swamp white oak (*Quercus bicolor* Willd.), bur oak (*Q. macrocarpa* Michx.), sycamore (*Platanus occidentalis* L.), and eastern cottonwood (*P. deltoides* Bartr. ex Marsh.).

▲ ***Stony Point Research Natural Area*** *is located on the Chippewa National Forest in northern Minnesota. The understory in this old-growth black ash swamp is a spectacular thicket of stinging nettles. See Hale (1996). Photo 9/93 by Lucy Tyrrell.*

As elms have succumbed to Dutch elm disease and elm yellows, elm representation has decreased over the past several decades. At present, elms occur primarily in the understory. Conifers are rarely present.

Highbush blueberry (*Vaccinium corymbosum* L.), black chokeberry (*Aronia melanocarpa* [Michx.] Elliott), and holly (*Ilex* L.) are common shrubs. If the shrub layer is poorly developed, a continuous ground cover of mosses and ferns is usually present.

PHYSICAL CONTEXT

Physiographic Provinces

The hardwood wetland forests occur in the following physiographic provinces (after Fenneman 1938):

Coastal Plain	(Embayed, Sea Island, East Gulf and Mississippi Alluvial sections)
Piedmont	(all sections)
Ridge and Valley	(Hudson-Champlain and Middle sections)
Appalachian Plateaus	(Alleghany Mountain, Unglaciated and Glaciated Alleghany Plateau, Catskill Mountains, and Mohawk sections)
New England	(Green Mountain, Taconic, Upland and Seaboard Lowland sections)
Interior Low Plateau	(all sections)
Central Lowland	(all sections)

Ecological Units

Hardwood wetland forests occur in several divisions and provinces (see Keys *et al.* 1995):

▲ *This old-growth elm-ash-maple swamp is located in the floodplain of the* ***Sturgeon River*** *on the Hiawatha National Forest in Michigan. The coarse woody debris visible in the photograph consists of elm snags and silver maple logs. Based on stand records, this stand originated in 1890. Photo 6/92 by Lucy Tyrrell.*

200	Humid Temperate Domain
210	Warm Continental Division
212	Laurentian Mixed Forest Province
220	Hot Continental Division
221	Eastern Broadleaf Forest (Oceanic) Province
222	Eastern Broadleaf Forest (Continental) Province
230	Subtropical Division
231	Southeastern Mixed Forest Province
232	Outer Coastal Plain Mixed Forest Province
234	Lower Mississippi Riverine Forest Province
M210	Warm Continental Regime Mountains
M212	Adirondack-New England Mixed Forest-Coniferous Forest-Alpine Meadow Province
M220	Hot Continental Regime Mountains
M221	Central Appalachian Broadleaf Forest-Coniferous Forest-Meadow Province

Geographic Distribution

Hardwood wetland forests occur primarily in the north and central tiers of States, ranging from southern Minnesota through Arkansas in the West to the Carolinas northward to southern Maine in the East. In Minnesota, Wisconsin, and Michigan, the northern limit roughly corresponds to the vegetative tension zone. These forests occur mainly in nonriverine, upland basins (*e.g.*, kettleholes), although they can be found along smaller drainages (1st-4th order streams) and along the margins of Coastal Plain ponds and bays.

Soils

Because of their topographic position, high water tables prevail (soil mottling close to the surface), and most sites are moist to wet throughout the year. These wetlands are typically oligotrophic, although they may be fertile in the South. Soils can be either mineral or organic and neutral to slightly acid.

DISTURBANCE

Topographic position and moist soils help protect these forests from fire. Since high water tables restrict rooting and limit tree anchorage, these forests are prone to windthrow, resulting in many tip-up mounds, downed trees, and canopy gaps. Trees may also be killed by fluctuating water levels and flooding due to beaver activity.

RELATION TO OTHER FOREST TYPES

Hardwood wetland forests differ from seasonally wet oak-hardwoods in that they: (1) lack seasonal dryness, (2) have fewer oaks, and (3) rarely burn, if at all. Small stands of hardwood wetland forest may occur within wetter sections of seasonally wet oak-hardwood woodlands.

STRUCTURAL CHARACTERISTICS OF OLD-GROWTH STANDS

Information about hardwood wetland forests in an old-growth condition is included in Figure 8 and Tables 47 through 56.

SELECTED REPRESENTATIVE OLD-GROWTH STANDS

Indiana

Spicer Lake, St. Joseph Co.
(Lindsey *et al.* 1969)

Wabash and Tippecanoe Rivers
(Lindsey *et al.* 1961)

Maine

Black Gum Swamp, New Glouster
(Vogelmann 1976)

Massachusetts

Orange Black Gum Swamp, Town of Orange, Franklin Co.
(Davis 1993)

Ohio

[areas in] Black Swamp Region, Northwest Ohio
(Gordon 1969)

Blacklick Woods, Fairfield Co.
(Sudia 1960)

Drew Woods, Darke Co.
(Boerner and Kooser 1991)

Goll Woods, Fulton Co.
(Boerner and Cho 1987)

Vermont

Brandon Swamp, Rutland Co.

Cornwall Swamp, Addison Co.

Leicester Junction Swamp, Addison and Rutland Co.

Town Swamp, Chittenden Co.

Vernon Black Gum Swamp, Windham Co.
(Davis 1993)

FOR ADDITIONAL INFORMATION

Additional references that pertain to hardwood wetland forests but are not cited in tables or text are listed by forest type group in Appendix C.

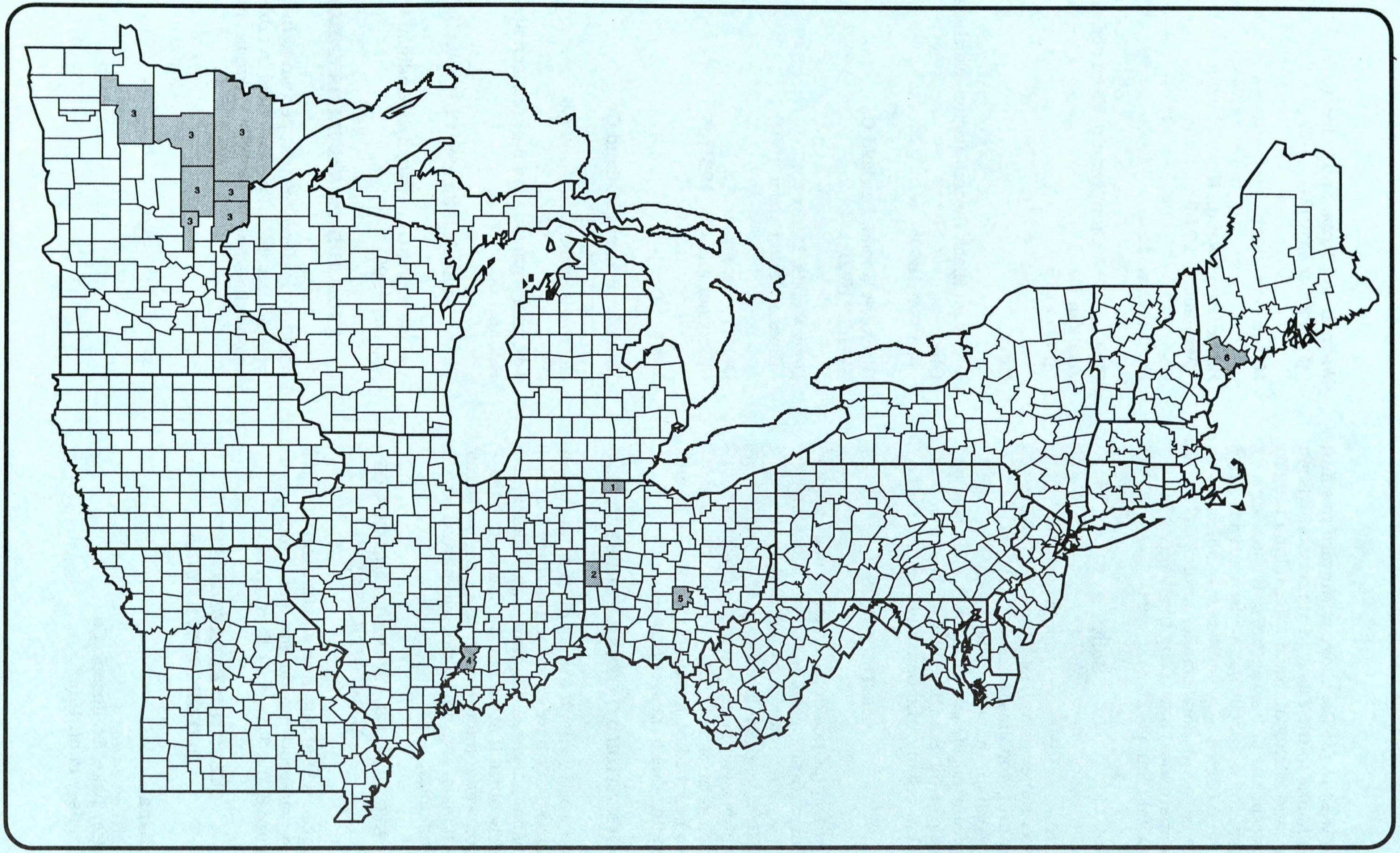
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Figure 8.—*General location of studies that provide stand structure information about old-growth hardwood wetland forests. Shaded counties contain at least one study. Numbers correspond to the cited references listed under Map Key below and in Tables 47 through 56. States are indicated using two-letter postal abbreviations.*

Map Key	Source/Date	State or Province	County	Map Key	Source/Date	State or Province	County
1	Boerner and Cho 1987	OH	Fulton	4	Lindsey et al. 1961	IN	Knox
2	Boerner and Kooser 1991	OH	Darke	5	Sudia 1960	OH	Fairfield
3	Hale 1996	MN	Aitkin, Betrami, Carlton, Itasca, Mille Lacs, Pine, St. Louis	6	Vogelmann 1976	ME	Cumberland

Table 47.—*Location, size, and elevation of hardwood wetland old-growth study sites.*

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
1	Boerner and Cho 1987	Goll Woods	OH	Fulton	78	unspecified
2	Boerner and Kooser 1991	Drew Woods State Nature Preserve	OH	Darke	6.5	unspecified
3	Hale 1996	Battle River	MN	Beltrami	8	1178
3	Hale 1996	Hay Creek	MN	Pine	8	900
3	Hale 1996	Jay Cooke	MN	Carlton	4	980
3	Hale 1996	Kathio St. Park	MN	Mille Lacs	12	1250
3	Hale 1996	Lost Lake	MN	St. Louis	23	1360
3	Hale 1996	Stony Point RNA	MN	Itasca	57	1310
3	Hale 1996	Sugar Point	MN	Itasca	5	1250
3	Hale 1996	Washkish	MN	Beltrami	8	1202
3	Hale 1996	Windigo	MN	Itasca	10	1330
3	Hale 1996	Wolf Lake	MN	Aitkin	5	1270
4	Lindsey et al. 1961	Big Swan Pond	IN	Knox	4.9	unspecified
4	Lindsey et al. 1961	Wabash [1]	IN	Knox	1.2	unspecified
5	Sudia 1960	Blacklick Woods	OH	Fairfield	24 [2]	unspecified
6	Vogelmann 1976	Black Gum Swamp	ME	Cumberland	2	152

[1] Site is located 100 miles upriver from mouth of the Wabash River.

[2] Area is for entire Blacklick Woods.

Table 48.—*Criteria used by sources to identify old-growth stands, and information about stand composition of hardwood wetland old-growth study sites.*

Map Key	Source/Date	Stand	Criteria for Stand Selection and Stand Composition
1	Boerner and Cho 1987	Goll Woods	Old-growth forest remnant; elm-ash-maple-oaks [1]
2	Boerner and Kooser 1991	Drew Woods State Nature Preserve	Old-growth; undisturbed, no cutting since 1855 [2]; bottomland swamp; white oak (33%) [3] -swamp white oak
3	Hale 1996	Battle River	Stand age >120 yr; no significant natural or human disturbance visible; black ash (53%)
3	Hale 1996	Hay Creek	Stand age >120 yr; no significant natural or human disturbance visible; black ash (33%)
3	Hale 1996	Jay Cooke	Stand age >120 yr; no significant natural or human disturbance visible; black ash (30%)
3	Hale 1996	Kathio St. Park	Stand age >120 yr; no significant natural or human disturbance visible; black ash (33%)
3	Hale 1996	Lost Lake	Stand age >120 yr; no significant natural or human disturbance visible; black ash (100%)
3	Hale 1996	Stony Point RNA	Stand age >120 yr; no significant natural or human disturbance visible; black ash (41%)
3	Hale 1996	Sugar Point	Stand age >120 yr; no significant natural or human disturbance visible; black ash (40%)
3	Hale 1996	Washkish	Stand age >120 yr; no significant natural or human disturbance visible; black ash (57%)
3	Hale 1996	Windigo	Stand age >120 yr; no significant natural or human disturbance visible; black ash (80%)
3	Hale 1996	Wolf Lake	Stand age >120 yr; no significant natural or human disturbance visible; black ash (70%)
4	Lindsey et al. 1961	Big Swan Pond	Well-drained second-growth on broad bottomlands; American elm (26%)-hackberry-hickory
4	Lindsey et al. 1961	Wabash	Poorly-drained bottomland flats; red maple-elm-hickory
5	Sudia 1960	Blacklick Woods	Few trees cut (mostly white ash); no canopy opening over stumps; mixture of elm-ash-maple and beech-maple
6	Vogelmann 1976	Black Gum Swamp	Nearly untouched, basically a virgin stand; several cut stumps near the edges; blackgum-hemlock-red maple

[1] Oaks were white, bur, chinkapin.

[2] Elsewhere in the region, draining and cutting has obliterated virtually all mature, native community types.

[3] Composition by basal area.

Table 49.—*Methods used to study old-growth hardwood wetlands (condensed from the cited references).*

Map Key	Source/Date	Stand	Sampling
1	Boerner and Cho 1987	Goll Woods	44 pairs of 10 m x 10 m quadrats placed randomly on 7 N-S transects
2	Boerner and Kooser 1991	Drew Woods State Nature Preserve	25 10 m x 10 m plots along 4 N-S transects
3	Hale 1996	Battle River	1 20 m x 50 m plot
3	Hale 1996	Hay Creek	1 20 m x 50 m plot
3	Hale 1996	Jay Cooke	1 20 m x 50 m plot
3	Hale 1996	Kathio St. Park	1 20 m x 50 m plot
3	Hale 1996	Lost Lake	1 20 m x 50 m plot
3	Hale 1996	Stony Point RNA	1 20 m x 50 m plot
3	Hale 1996	Sugar Point	1 20 m x 50 m plot
3	Hale 1996	Washkish	1 20 m x 50 m plot
3	Hale 1996	Windigo	1 20 m x 50 m plot
3	Hale 1996	Wolf Lake	1 20 m x 50 m plot
4	Lindsey et al. 1961	Big Swan Pond	7 0.08-ha strips
4	Lindsey et al. 1961	Wabash	Randomly placed strips
5	Sudia 1960	Blacklick Woods	All trees in 4.5-ha area mapped and measured
6	Vogelmann 1976	Black Gum Swamp	Ring count in 10 cm section of wood cut from edge of stand

Table 50.—*Density of live trees ≥10, ≥50, and ≥70 cm for hardwood wetland old-growth study sites. For other minimum sizes, the density is listed under "≥X cm", with the minimum size for tallying trees given as "Min Diam X (cm)".*

			Live Tree Density				
Map Key	**Source/Date**	**Stand**	**≥10 cm (#/ha)**	**≥50 cm (#/ha)**	**≥70 cm (#/ha)**	**≥X (#/ha)**	**Min Diam X (cm)**
1	Boerner and Cho 1987	Goll Woods				162 [1]	2.5
2	Boerner and Kooser 1991	Drew Woods State Nature Preserve				800	2.5
3	Hale 1996	Battle River	375	0	0		
3	Hale 1996	Hay Creek	688	13	0		
3	Hale 1996	Jay Cooke	675	13	0		
3	Hale 1996	Kathio St. Park	488	38	0		
3	Hale 1996	Lost Lake	1263	0	0		
3	Hale 1996	Stony Point RNA	488	50	0		
3	Hale 1996	Sugar Point	438	63	0		
3	Hale 1996	Washkish	1100	13	0		
3	Hale 1996	Windigo	1000	0	0		
3	Hale 1996	Wolf Lake	1225	13	0		
4	Lindsey et al. 1961	Big Swan Pond	281				
4	Lindsey et al. 1961	Wabash	247				
5	Sudia 1960	Blacklick Woods	305 [2]				
6	Vogelmann 1976	Black Gum Swamp					

[1] Value is for red maple, American elm, and black ash only.

[2] Value given is for species in both forest types (beech-maple and elm-red maple-ash). For elm-red maple-ash only, tree density is 152 per hectare.

Table 51.—*Basal area of live trees ≥10, ≥50, and ≥70 cm for hardwood wetland old-growth study sites. For other minimum sizes, the basal area is listed under "≥X cm", with the minimum size for tallying trees given as "Min Diam X (cm)".*

			Live Tree Basal Area (BA)				
Map Key	**Source/Date**	**Stand**	**≥10 cm (m^2/ha)**	**≥50 cm (m^2/ha)**	**≥70 cm (m^2/ha)**	**≥X cm (m^2/ha)**	**Min Diam X (cm)**
1	Boerner and Cho 1987	Goll Woods					
2	Boerner and Kooser 1991	Drew Woods State Nature Preserve				36.7	2.5
3	Hale 1996	Battle River	27.6				
3	Hale 1996	Hay Creek	44.4				
3	Hale 1996	Jay Cooke	38.1				
3	Hale 1996	Kathio St. Park	32.5				
3	Hale 1996	Lost Lake	37.3				
3	Hale 1996	Stony Point RNA	32.0				
3	Hale 1996	Sugar Point	36.0				
3	Hale 1996	Washkish	34.3				
3	Hale 1996	Windigo	38.6				
3	Hale 1996	Wolf Lake	57.0				
4	Lindsey et al. 1961	Big Swan Pond	24.7				
4	Lindsey et al. 1961	Wabash	22.0				
5	Sudia 1960	Blacklick Woods	29.1 [1]				
6	Vogelmann 1976	Black Gum Swamp					

[1] Value given is for species in both forest types (beech-maple and elm-red maple-ash). For elm-red maple-ash only, basal area is 11 m^2/ha.

Table 52.—*Average and maximum tree age by species for hardwood swamp old-growth wetland sites.*

Map Key	Source/Date	Stand	Average Age (yr)	Maximum Age (yr)			
			Any Species	Elm spp.	Black Ash	Yellow Birch	Blackgum
1	Boerner and Cho 1987	Goll Woods					
2	Boerner and Kooser 1991	Drew Woods State Nature Preserve					
3	Hale 1996	Battle River	139 [1]				
3	Hale 1996	Hay Creek	234 [2]		264 [3]	195 [3]	
3	Hale 1996	Jay Cooke	168 [2]		186 [3]		
3	Hale 1996	Kathio St. Park	143 [2]		171 [3]	100 [3]	
3	Hale 1996	Lost Lake	157 [1]				
3	Hale 1996	Stony Point RNA	144 [2]	113 [3]	218 [3]		
3	Hale 1996	Sugar Point					
3	Hale 1996	Washkish	141 [1]				
3	Hale 1996	Windigo	185 [1]				
3	Hale 1996	Wolf Lake	197 [2]				
4	Lindsey et al. 1961	Big Swan Pond					
4	Lindsey et al. 1961	Wabash					
5	Sudia 1960	Blacklick Woods					
6	Vogelmann 1976	Black Gum Swamp					400 [4]

[1] Average of 5 oldest trees of 10 cored in old-growth in stand evaluation survey by the Department of Natural Resources.

[2] Average of 5 oldest trees of 10 cored in this study.

[3] A few cores were taken in or near sample plots; age is not likely to be stand maximum.

[4] Age extrapolated from ring count in 10-cm piece of wood. Taller trees reached 24-27 m.

Table 53.—*Maximum tree diameter by species, and the percentage of the tree canopy in gaps for hardwood wetland old-growth study sites.*

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm) Elm spp.	Ash spp.	Red Maple	Blackgum	Eastern Hemlock	Oak spp.	Canopy Gaps (%)
1	Boerner and Cho 1987	Goll Woods						100 [1]	
2	Boerner and Kooser 1991	Drew Woods State Nature Preserve							
3	Hale 1996	Battle River							
3	Hale 1996	Hay Creek							
3	Hale 1996	Jay Cooke							
3	Hale 1996	Kathio St. Park							
3	Hale 1996	Lost Lake							
3	Hale 1996	Stony Point RNA							
3	Hale 1996	Sugar Point							
3	Hale 1996	Washkish							
3	Hale 1996	Windigo							
3	Hale 1996	Wolf Lake							
4	Lindsey et al. 1961	Big Swan Pond							
4	Lindsey et al. 1961	Wabash							
5	Sudia 1960	Blacklick Woods							
6	Vogelmann 1976	Black Gum Swamp			25	58	76		

[1] Oaks were white, bur, chinkapin.

Table 54.—*Density, basal area, volume, and minimum diameter measured for standing dead trees (snags) on hardwood wetland old-growth study sites.*

Map Key	Source/Date	Stand	Standing Dead Trees (Snags) Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Snag Volume (m^3/ha)	Min Snag Diam (cm)
1	Boerner and Cho 1987	Goll Woods				
2	Boerner and Kooser 1991	Drew Woods State Nature Preserve				
3	Hale 1996	Battle River	225		129.3	10
3	Hale 1996	Hay Creek	88		23.4	10
3	Hale 1996	Jay Cooke	50		6.3	10
3	Hale 1996	Kathio St. Park	75		13.7	10
3	Hale 1996	Lost Lake	38		4.4	10
3	Hale 1996	Stony Point RNA	138		54.6	10
3	Hale 1996	Sugar Point	113		87.5	10
3	Hale 1996	Washkish	25		5.5	10
3	Hale 1996	Windigo	113		12.8	10
3	Hale 1996	Wolf Lake	75		12.9	10
4	Lindsey et al. 1961	Big Swan Pond				
4	Lindsey et al. 1961	Wabash				
5	Sudia 1960	Blacklick Woods				
6	Vogelmann 1976	Black Gum Swamp				

Table 55.—*Density, volume, and minimum diameter measured for fallen dead trees (logs) on hardwood wetland old-growth study sites.*

Map Key	Source/Date	Stand	Fallen Dead Trees (Logs) Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)
1	Boerner and Cho 1987	Goll Woods			
2	Boerner and Kooser 1991	Drew Woods State Nature Preserve			
3	Hale 1996	Battle River	638	142.1[1]	10
3	Hale 1996	Hay Creek	450	49.9[1]	10
3	Hale 1996	Jay Cooke	613	200.9[1]	10
3	Hale 1996	Kathio St. Park	288	71.3[1]	10
3	Hale 1996	Lost Lake	238	34.5[1]	10
3	Hale 1996	Stony Point RNA	288	35.1[1]	10
3	Hale 1996	Sugar Point	463	111.3[1]	10
3	Hale 1996	Washkish	438	177.8[1]	10
3	Hale 1996	Windigo	475	108.6[1]	10
3	Hale 1996	Wolf Lake	525	142.4[1]	10
4	Lindsey et al. 1961	Big Swan Pond			
4	Lindsey et al. 1961	Wabash			
5	Sudia 1960	Blacklick Woods			
6	Vogelmann 1976	Black Gum Swamp			

[1] Volume of logs reported was based on outside dimensions ("measured volume"); when hollow areas are subtracted, volume is less ("adjusted volume").

Table 56.—*Summary of attributes for old-growth hardwood wetland stands (from Tables 47 through 55).*

Attribute	Range	References (Map Key)
Live Tree Density (#/ha)		
- Trees ≥ 2.5 cm d.b.h.	162 - 800	1, 2
- Trees ≥ 10 cm d.b.h.	247 - 1263	3, 4, 5
- Trees ≥ 50 cm d.b.h.	0 - 63	3
- Trees ≥ 70 cm d.b.h.	0	3
Live Tree Basal Area (m^2/ha)		
- Trees ≥ 2.5 cm d.b.h.	36.7	2
- Trees ≥ 10 cm d.b.h.	22.0 - 57.0	3, 4, 5
- Trees ≥ 50 cm d.b.h.	--	--
- Trees ≥ 70 cm d.b.h.	--	--
Tree or Stand Age (yr)		
Average Age by Species		
- Not specified	139 - 234	3
Maximum Age by Species*		
- Elm spp.	113	3
- Black Ash	171 - 264	3
- Yellow Birch	100 - 195	3
- Blackgum	400	6
Maximum Tree Diameter at Breast Height by Species (cm)		
- Ash spp.		
- Blackgum	58	6
- Elm spp.		
- Hemlock	76	6
- Oak spp.	100	1
- Red Maple	25	6

(Table 56 continued on next page)

(Table 56 continued)

Attribute	Range	References (Map Key)
Canopy Gaps (%)	--	--
Standing Dead Trees (Snags)		
Snag Density (#/ha)		
- Snags ≥ 10 cm d.b.h.	25 - 225	3
Snag Basal Area (m^2/ha)		
- Snags ≥ 10 cm d.b.h.	--	--
Snag Volume (m^3/ha)		
- Snags ≥ 10 cm d.b.h.	4.4 - 129.3	3
Fallen Dead Trees (Logs)		
Density of Logs (#/ha)		
- Logs ≥ 10 cm d.b.h.	238 - 638	3
Volume of Logs (m^3/ha)		
- Logs ≥ 10 cm d.b.h.	34.5 - 200.9	3

*oldest of cores taken but not necessarily maximum age in stand.

CONIFER-NORTHERN HARDWOOD FORESTS

COMMUNITY COMPOSITION

Forest Cover Types

The following Society of American Foresters (SAF) forest cover types (Eyre 1980) are included in the conifer-northern hardwood forest type group:

20 - white pine-northern red oak-red maple
21 - eastern white pine
22 - white pine-hemlock
23 - eastern hemlock
24 - hemlock-yellow birch
30 - red spruce-yellow birch
31 - red spruce-sugar maple-beech
35 - paper birch-red spruce-balsam fir

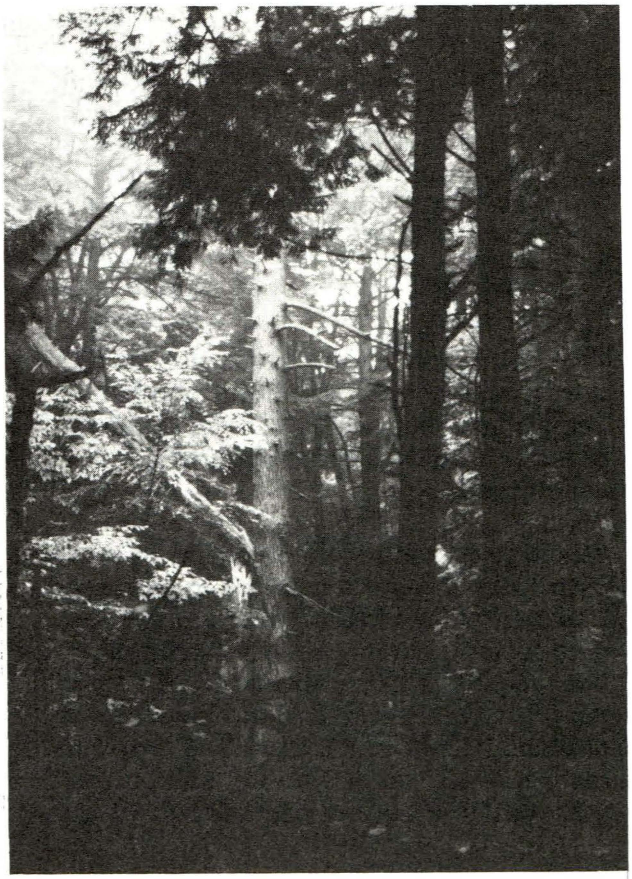
The following Combined Data Systems (CDS) forest cover types for the USDA Forest Service Eastern Region (USDA 1974) are included in the conifer-northern hardwood forest type group:

4 - white pine/hemlock
5 - hemlock
9 - conifers
41 - white pine/northern red oak/white ash
87 - sugar maple/beech/yellow birch/red spruce

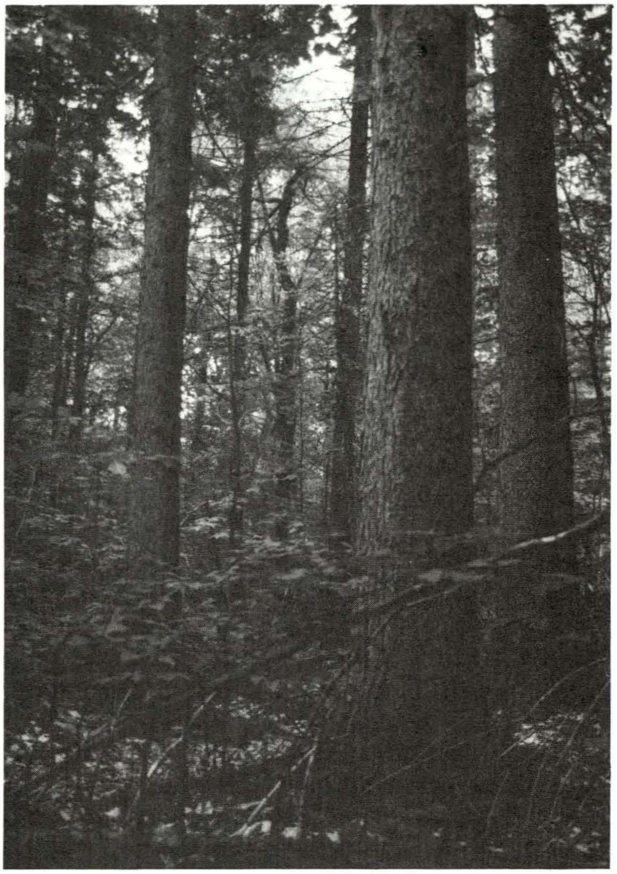
Species Composition

Conifer-northern hardwood forests are comprised of various mixtures of coniferous and broadleaf trees, with at least 25 percent of the overstory canopy in conifers or hardwoods. The dominant conifer of conifer-northern hardwood forests is eastern hemlock (*Tsuga canadensis* [L.] Carr.), eastern white pine (*Pinus strobus* L.), or red spruce (*Picea rubens* Sarg.), although mixtures of several conifers often occur in a given stand.

Hemlock-dominated.—Eastern Hemlock is considered a wet-mesic species, developing best on cool, moderately well- to somewhat poorly-drained sites. Main associates are yellow birch (*Betula alleghaniensis* Britton), sugar maple (*A. saccharum* Marsh.), American beech (*Fagus grandifolia* Ehrh.), red maple (*Acer rubrum* L.), and eastern white pine. Because of its dense foliage, eastern hemlock greatly limits light penetration to the forest



▶ ***Hearts Content*** *is a well-studied hemlock-hardwood forest in northwestern Pennsylvania on the Allegheny National Forest. See Lutz (1930c), Morey (1936a, 1936b), Whitney (1984), and Tritton and Siccama (1990). Photo 8/89 by Lucy Tyrrell.*



▲ ***Big Reed Pond Preserve*** *in northern Maine is a large landscape of old-growth mixed woods, as illustrated in this photo (hardwoods, red spruce, and balsam fir), as well as northern hardwood forests, spruce-fir forests, and northern white-cedar wetlands. From left to right, prominent red spruce in the photo measured 36 cm, 46 cm, and 50 cm diameter at breast height. See Cogbill (1985) and Widoff (1985). Photo 7/92 by Lucy Tyrrell.*

floor. Thus, understory vegetation varies greatly according to overstory conditions: being sparse beneath hemlocks, common beneath hardwoods, and abundant within canopy gaps.

Yellow birch and red maple are most common associates of eastern hemlock in wet areas. However, many moisture-tolerant species may occur, including balsam fir (*Abies balsamea* [L.] Mill.), paper birch (*B. papyrifera* Marsh.), black spruce (*Picea mariana* [Mill.] B.S.P.), black ash (*Fraxinus nigra* Marsh.), elm (*Ulmus* L.), and northern white-cedar (*Thuja occidentalis* L.).

Eastern white pine-dominated.—The distribution of eastern white pine-northern hardwood forests is closely related to historical fire patterns. White pine is more likely to be the dominant conifer at the dry end of the conifer-northern hardwood complex, occupying sites more likely to burn. However, white pine-northern hardwood mixtures do occur on moist sites. Common associates include red maple, paper birch, and northern red oak (*Quercus rubra* L.) on dry sites and sugar maple, American beech, yellow birch, white ash (*F. americana* L.), and eastern hemlock on moist sites.

Red spruce-dominated.—This mixture occurs on cool microsites, but only in those States along the Appalachian chain from Maine to North Carolina. In New England, red spruce-northern hardwoods can be found in various topographic locations. However, they most frequently occur at mid-elevations where montane spruce and northern hardwood forests intergrade (Bormann *et al.* 1970, Cogbill and White 1991). Moving south along the Appalachians, one finds that the transition occurs at progressively higher elevations according to regional changes in temperature. In the southern Appalachians, many red spruce-northern hardwoods occur only on mountaintops. Since this mixture is prevalent in mountainous terrain, sites are normally steep, and soils shallow and rocky. Common associates vary greatly among locations and include yellow birch, sugar maple, American beech, red maple, eastern white pine, balsam fir, sweet birch (*Betula lenta* L.), and paper birch.

PHYSICAL CONTEXT

Physiographic Provinces

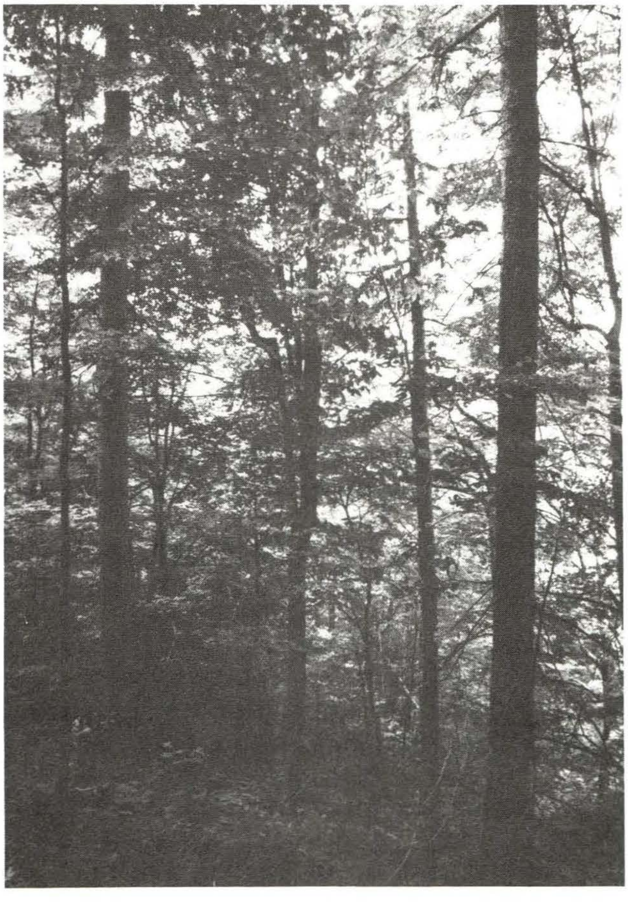
Conifer-northern hardwood forests occur in the following physiographic provinces (after Fenneman 1938):

Piedmont	(Lowland section)
Blue Ridge	(all sections)
Ridge and Valley	(all sections)
Appalachian Plateaus	(all sections)
New England	(all sections)
Adirondack	
Central Lowland	(Great Lake, Driftless, and Western Young Drift sections)
Superior Upland	

Ecological Units

Conifer-northern hardwood forests occur in several divisions and provinces (see Keys *et al.* 1995):

200 Humid Temperate Domain
210 Warm Continental Division
212 Laurentian Mixed Forest Province
220 Hot Continental Division
221 Eastern Broadleaf Forest (Oceanic) Province
M210 Warm Continental Regime Mountains
M212 Adirondack-New England Mixed Forest-Coniferous Forest-Alpine Meadow Province
M220 Hot Continental Regime Mountains
M221 Central Appalachian Broadleaf Forest-Coniferous Forest-Meadow Province



▲ *The upper slopes of* ***The Cape Research Natural Area****, Green Mountain National Forest, Vermont, are occupied by red spruce-hardwoods. The large red spruce at left measured 58.0 cm in diameter at breast height. Photo 7/92 by Lucy Tyrrell.*

Geographic Distribution

The distribution of conifer-northern hardwood forests is similar to that of northern hardwoods. They cover the northern tier of States from Minnesota to Maine and extend southward along the Appalachian Mountains to north Georgia. Moving south along the Appalachian chain one finds that the cool temperatures required by species of this forest type group restrict these forests to progressively higher elevations. In the southern Appalachians, cool sites are found primarily on north- and east-facing slopes.

Soils

In the North, conifer-northern hardwoods typically grow on Alfisols, Inceptisols, or Spodosols, ranging from dry mesic to wet mesic. Soil nutrient availability greatly influences the competitiveness of conifers and hardwoods. In general, conifers are more successful on nutrient-poor sites and hardwoods on nutrient-rich sites. Hence, conifer-hardwood mixtures usually develop best on sites intermediate in fertility where there is no distinct competitive advantage for either tree group.

Soils in hemlock-dominated forests are more likely to be covered with needles and twigs. Acids released by decomposing coniferous debris on the surface aid in soil podsolization; in turn, many soils are Spodosols or Inceptisols with spodic tendencies. Some hemlock-northern hardwood forests are found in depressions or seepage areas that receive groundwater discharge, frequently along swamp margins. The fertility of these wet areas varies, depending largely on the mineral concentration of groundwater inflow. Flooding is common, particularly during and immediately after winter snow melt. Soils in white pine-dominated stands are coarse- to medium-textured.

DISTURBANCE

Windthrow

Windthrow is particularly common where high water tables limit downward growth of tree roots; creating shallow rooting patterns. This disturbance allows for frequent gap-phase regeneration, and windthrown trees provide sites for eastern hemlock and yellow birch regeneration. Pit-and-mound microtopography is characteristic of hemlock-northern hardwood forests. Because of relatively moist conditions that prevail in hemlock-northern hardwood forests, storms have influenced stand dynamics more than fire.

Fire

Fire and other disturbances have greatly helped maintain eastern white pine by creating conditions that encourage pine regeneration or stand initiation (*e.g.*, reducing hardwood competition, exposing mineral soil, increasing forest-floor light levels, etc.). Indeed, most of the impressive eastern white pine-northern hardwood forests present before European settlement resulted from large-scale fires centuries earlier. Such events have been documented for the Great Lakes region (Graham 1941, Maissurow 1941), and for the Northeast (Cline and Spurr 1942, Hough and Forbes 1943).

Other Disturbance

Insect outbreaks, wind and ice storms, and fire are common in red spruce-northern hardwoods. Deer browsing, fire suppression, and climate change in relation to soil moisture may have hindered regeneration of eastern hemlock (*e.g.*, Frelich and Lorimer 1985). The preferential removal of certain conifers (*i.e.*, eastern white pine and eastern hemlock) and changes in the disturbance regime by Europeans (fire suppression, fragmentation preventing widespread fire pathways) have reduced the occurrence of this forest type group in many locations (Elliott 1953, Goodlett 1954, Whitney 1990).

RELATIONSHIP TO OTHER FOREST TYPES

Stands with a high percentage of eastern white pine and less than 25 percent hardwoods will merge into the northern pine forest type group. With increasing elevation, the hardwood component in red spruce-hardwood stands becomes less than 25 percent and the stands transition to the montane spruce-fir forest type group. At lower elevations, the spruce drops out, resulting in northern hardwood forests. Hemlock-hardwood stands also grade into northern hardwood stands if hemlock is less than 25 percent. Nearly pure eastern hemlock stands remain classified as conifer-hardwoods.

STRUCTURAL CHARACTERISTICS OF OLD-GROWTH STANDS

Information about conifer-northern hardwood forests in an old-growth condition is included in Figure 9 and Tables 57 through 66.

SELECTED REPRESENTATIVE OLD-GROWTH STANDS

Kentucky

Lilly Cornett Woods*, Letcher Co.
(Nowacki and Trianosky 1993)

Maine

Adams Pond, Town of Bridgton, Cumberland Co.
(Maine Critical Areas Program 1983b)

Big Reed Pond Preserve*, Piscataquis Co.
(Cogbill 1985, Widoff 1985)

Cobbosseecontee*, Town of Monmouth, Kennebec Co.
(Conkling 1978, Davis 1993, Maine Critical Areas Program 1983b)

Cold Brook, Town of Dead River, Somerset Co.
(Maine Critical Areas Program 1983b)

Farm Cove Mountain, Washington Co.
(Maine Critical Areas Program 1983b)

Fryeburg Stand, Town of Fryeburg, Oxford Co.
(Davis 1993, Stern 1982)

Mahoosuc Notch, Town of Grafton, Oxford Co.
(Davis 1993, Hudson *et al.* 1986, Maine Critical Areas Program 1983b, Maine State Planning Office 1986)

Mattawamkeag, Winn Township, Penobscot Co.
(Maine Critical Areas Program 1983b)

Mount Christopher, Town of Greenwood, Oxford Co.
(Maine Critical Areas Program 1983b)

Number 3 Pond, Penobscot Co.
(Davis 1993, Maine Critical Areas Program 1983b)

◄ *Old-growth red spruce-hardwoods can be viewed from the Crawford Path passing through **Gibbs Brook candidate Research Natural Area** on the White Mountain National Forest in New Hampshire. This photograph, taken at an elevation of about 650 m, includes a view of a red spruce snag (left of center), yellow birch (right of center), red spruce (right) and balsam fir (foreground right). See Carbonneau (1986a). Photo 3/92 by Lucy Tyrrell.*

Ocean Park, Town of Old Orchard Beach, York Co.
(Maine Critical Areas Program 1983b)

Pleasant Lake, Washington Co.
(Maine Critical Areas Program 1983b)

Prentiss Wood, Town of Bangor, Penobscot Co.
(Maine Critical Areas Program 1983b)

Sabao Lake, Hancock Co.
(Maine Critical Areas Program 1983b)

Thomas Point, Town of Westport, Lincoln Co.
(Maine Critical Areas Program 1983b)

Waldoboro, Lincoln Co.
(Maine Critical Areas Program 1983b)

Wassataquoik Mountain/Lake/Stream, Penobscot Co.
(Davis 1993, Hudson *et al.* 1986, Maine Critical Areas Program 1983b, Maine State Planning Office 1986)

Massachusetts

Cold River Watershed-Black Brook*
(Davis 1993, Dunwiddie 1993, Leverett 1988)

Dunbar Brook Watershed, Franklin Co.
(Dunwiddie 1993)

Fife Brook Ravine
(Davis 1993, Dunwiddie 1993, Leverett 1988)

Ice Glenn, Town of Stockbridge
(Davis 1993)

Mount Greylock State Reservation, Berkshire Co.
(Davis 1993, Dunwiddie 1993)

Todd Mountain*, near Mohawk Trail State Forest
(Davis 1993, Leverett 1988)

Michigan

Estivant Pines*, Keweenaw Co.
(Davis 1993)

Huron Mountain Club*, T52-53N R28-29W, MI
(Frelich and Lorimer 1991)

Little Presque Isle, Marquette Co.
(Davis 1993)

North Fox Island*, Leelanau Co.
(Davis 1993)

Northshore Research Natural Area*, Mackinaw State Forest
(Davis 1993)

Porcupine Mountains Wilderness State Park*
(Dahir and Lorimer 1996, Frelich and Lorimer 1991)

South Manitou Island*, Leelanau Co.
(Scott 1984, Scott and Murphy 1986)

Sylvania Wilderness Area*, Ottawa National Forest
(Frelich and Lorimer 1991, Tyrrell and Crow 1994)

Minnesota

Hovland Woods, Cook Co.
(Davis 1993)

Red Lake Peatland*, Beltrami Island/Pine Island State Forest
(Davis 1993)

New Hampshire

Barlett Experimental Forest*, White Mountain National Forest
(Leak 1985a, 1987a, 1987b)

Crawford Notch*, White Mountain National Forest
(Davis 1993; Foster and Reiners 1983, 1986; Worrall and Harrington 1988)

Gibbs Brook Scenic Area*, White Mountain National Forest
(Carbonneau 1986a)

Harvard Tract, Pisgah Forest
(Foster 1988)

Nancy Brook Research Natural Area*, White Mountain National Forest
(Davis 1993; Leak 1975, 1985b; Nowacki and Trianosky 1993)

The Bowl Research Natural Area*, White Mountain National Forest
(Davis 1993, Leak and Graber 1974)

New York

Ampersand Mountain*, Adirondack Park
(Davis 1993, Leopold *et al.* 1988)

Baldwin Hill, Adirondack Park
(Leopold *et al.* 1988)

Dead Creek Flow, Adirondack Park
(Davis 1993, Leopold *et al.* 1988)

Five Ponds Wilderness*, Adirondack Park
(Davis 1993, Leopold *et al.* 1988)

Huyck Preserve, near Albany
(Runkle 1982, 1991)

Kildare, Adirondack Park
(Davis 1993, Leopold *et al.* 1988)

McKenzie Mountain, Adirondack Park
(Davis 1993, Leopold *et al.* 1988)

Roaring Brook, Town of Keene, Essex Co.
(Davis 1993, Leopold *et al.* 1988)

◀ *Fallen dead wood (logs) and standing dead wood (snags) are part of the forest structure at* ***Patterson Hemlocks State Natural Area*** *in Oneida County, Wisconsin. The dominant conifers in this 10-ha relatively undisturbed stand are hemlock (55 percent) and white pine (20 percent). The estimated age of trees in this stand was upwards of 215 years. See Tyrrell (1988b) and Tyrrell and Crow (1994). Photo 1988 by Lucy Tyrrell.*

North Carolina

Craggy Mountain, Buncombe Co.
(Davis 1993, Roe 1987)

Great Smoky Mountains National Park*
(DeYoung 1979)

Joyce Kilmer Memorial Forest*, Graham Co.
(Oosting and Bourdeau 1955, Runkle 1982)

Kelsey Tract, Nantahala National Forest
(Davis 1993)

Linville Gorge*, Pisgah National Forest
(Davis 1993, Roe 1987)

Mackey Mountain*, Pisgah National Forest
(Davis 1993)

Moses Cone Memorial Park*, off Blue Ridge Parkway
(Davis 1993)

Mount Pisgah*, near Blue Ridge Parkway
(Davis 1993, Roe 1987)

Santeetlah Creek Bluffs, Graham Co.
(Davis 1993)

Side of Graveyard Ridge, Balsam Mountains
(Davis 1993)

Walker Cove Research Natural Area*, near Asheville
(Nowacki and Trianosky 1993; Runkle 1981, 1982, 1991; Runkle and Yetter 1987; Yetter and Runkle 1986)

Pennsylvania

Alan Seeger Natural Area*, Huntington Co.
(Davis 1993, Nowacki and Abrams 1994)

Bark Cabin, Lycoming Co.
(Davis 1993)

Bear Creek, Westmoreland Co.
(Donahue 1954)

Calendonia State Park, Franklin Co.
(Davis 1993)

Cook Forest State Park*, northwestern PA
(Morey 1936a, 1936b)

Detweiler Run Natural Area*, Huntington Co.
(Davis 1993, Erdman and Wiegman 1974, Nowacki and Abrams 1994)

Dingman Falls, Pike Co.
(Davis 1993)

Dunlo Flats, Cambria Co.
(Erdman and Wiegman 1974)

East Branch Swamp, Sproul State Forest, Clinton Co.
(Erdman and Wiegman 1974)

Forrest H. Dutinger Natural Area, Susquehannock State Park
(Davis 1993)

Hearts Content Scenic Area*, Allegheny National Forest
(Lutz 1930c; Morey 1936a, 1936b; Tritton and Siccama 1990; Whitney 1984)

Jerry Run, Elk State Forest, Cameron Co.
(Erdman and Wiegman 1974)

Joyce Kilmer Natural Area, Union Co.
(Erdman and Wiegman 1974)

Laurel Hill State Park, Somerset Co.
(Erdman and Wiegman 1974)

Laurel Run Natural Area, Perry Co.
(Davis 1993)

Lehigh Gorge, Carbon Co.
(Davis 1993)

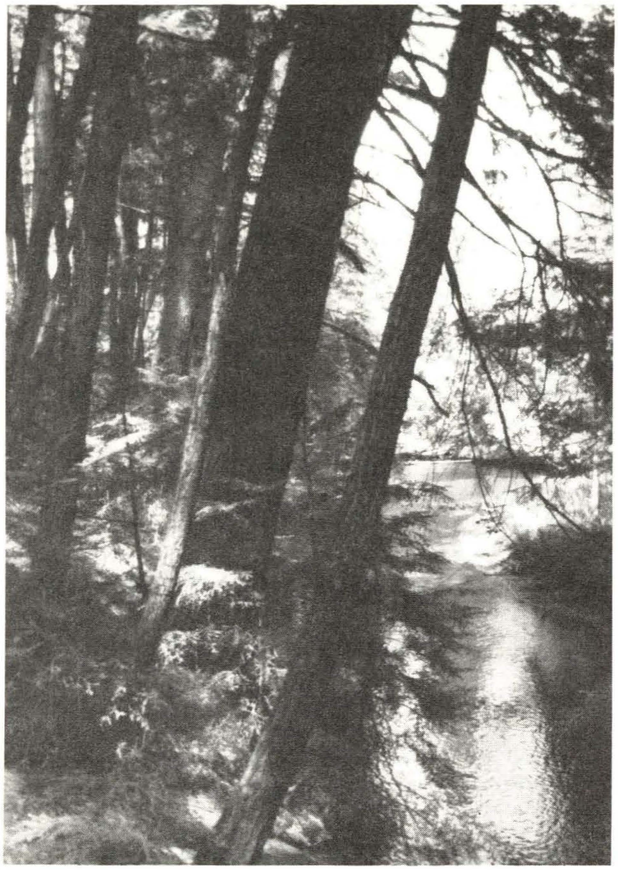
Lower Bear Island, lower Susquehanna River
(Erdman and Wiegman 1974)

Lowery Run, southeast of Emlenton, Butler Co.
(Erdman and Wiegman 1974)

McCormick Gorge, Butler Co.
(Erdman and Wiegman 1974)

Mount Logan, southeast of Castanea, Clinton Co.
(Erdman and Wiegman 1974)

Mount Riansares, northwest of Loganston, Clinton Co.
(Erdman and Wiegman 1974)



▲ *A stand of hemlock, white pine, and red pine along with some hardwoods at* ***Squaw Creek*** *on the Hiawatha National Forest in the Upper Peninsula of Michigan. The year of origin for the stand is 1860. Dominating the photograph is an 85-cm diameter white pine. Photo 6/92 by Lucy Tyrrell.*

Muddy Creek Research Natural Area, Crawford Co.
(Erdman and Wiegman 1974)

Ricketts Glen State Park, Sullivan and Wyoming Co.
(Meyer and Stevenson 1943)

Rockwood Reservoir, Somerset Co.
(Erdman and Wiegman 1974)

Silvermine Run*, east of Rector, Westmoreland Co.
(Erdman and Wiegman 1974)

Snyder-Middleswarth State Park, Snyder Co.
(Davis 1993)

Sweet Root Natural Area*, Bedford Co.
(Davis 1993)

Tall Timbers State Forest Natural Area, Snyder Co.
(Davis 1993)

The Hemlocks, Tuscarora State Forest, Perry Co.
(Davis 1993)

Tionesta Scenic and Research Natural Areas*, Allegheny National Forest
(Meyer and Stevenson 1943, Runkle 1982)

Trough Creek State Park*, Huntington Co.
(Erdman and Wiegman 1974)

Upper Bear Island, lower Susquehanna River
(Erdman and Wiegman 1974)

White Mountain Wild Area-McConnells Narrows, south of Weikert
(Erdman and Wiegman 1974)

Wolf Swamp, northwest of Hyndman, Bedford Co.
(Erdman and Wiegman 1974)

Woodbourne Forest and Wildlife Sanctuary*, Susquehanna Co.
(Runkle 1982)

World's End State Park, Sullivan Co.
(Erdman and Wiegman 1974)

Tennessee

Fall Creek Falls State Park*
(Caplenor 1965, Davis 1993)

Great Smoky Mountains National Park*
(DeYoung 1979)

Savage Gulf State Natural Area*, Grundy Co.
(Davis 1993, Quarterman *et al.* 1972)

Vermont

Battell Biological Preserve, Addison Co.
(Davis 1993)

East Mountain-Glastenbury, Bennington Co.
(Davis 1993)

Mayo Mountain, Chittenden Co.
(Davis 1993)

Tinker Brook State Natural Area, Windsor Co.
(Davis 1993)

Virginia

Bottom Creek Gorge
(Davis 1993)

Hunting Creek, Bedford Co.
(Davis 1993)

The Limberlost*, Shenandoah National Park
(Davis 1993)

Ramseys Draft Wilderness*, George Washington National Forest
(Halpin 1990)

Roaring Branch, north of Big Stone Gap
(Davis 1993)

West Virginia

Cathedral State Park*, east of Aurora, Preston Co.
(Bieri and Anliot 1965)

Gaudineer Scenic Area*, Monongahela National Forest
(Davis 1993)

Wisconsin

Bose Lake Research Natural Area, Nicolet National Forest
(Davis 1993)

Memorial Grove Hemlocks Research Natural Area, Chequamegon National Forest
(Tyrrell and Crow 1994)

Outer Island, Apostle Islands National Lakeshore
(Tyrrell and Crow 1994)

Plum Lake State Natural Area, Vilas Co.
(Tyrrell and Crow 1994)

FOR ADDITIONAL INFORMATION

Additional references that pertain to conifer-northern forests but are not cited in tables or text are listed by forest type group in Appendix C.

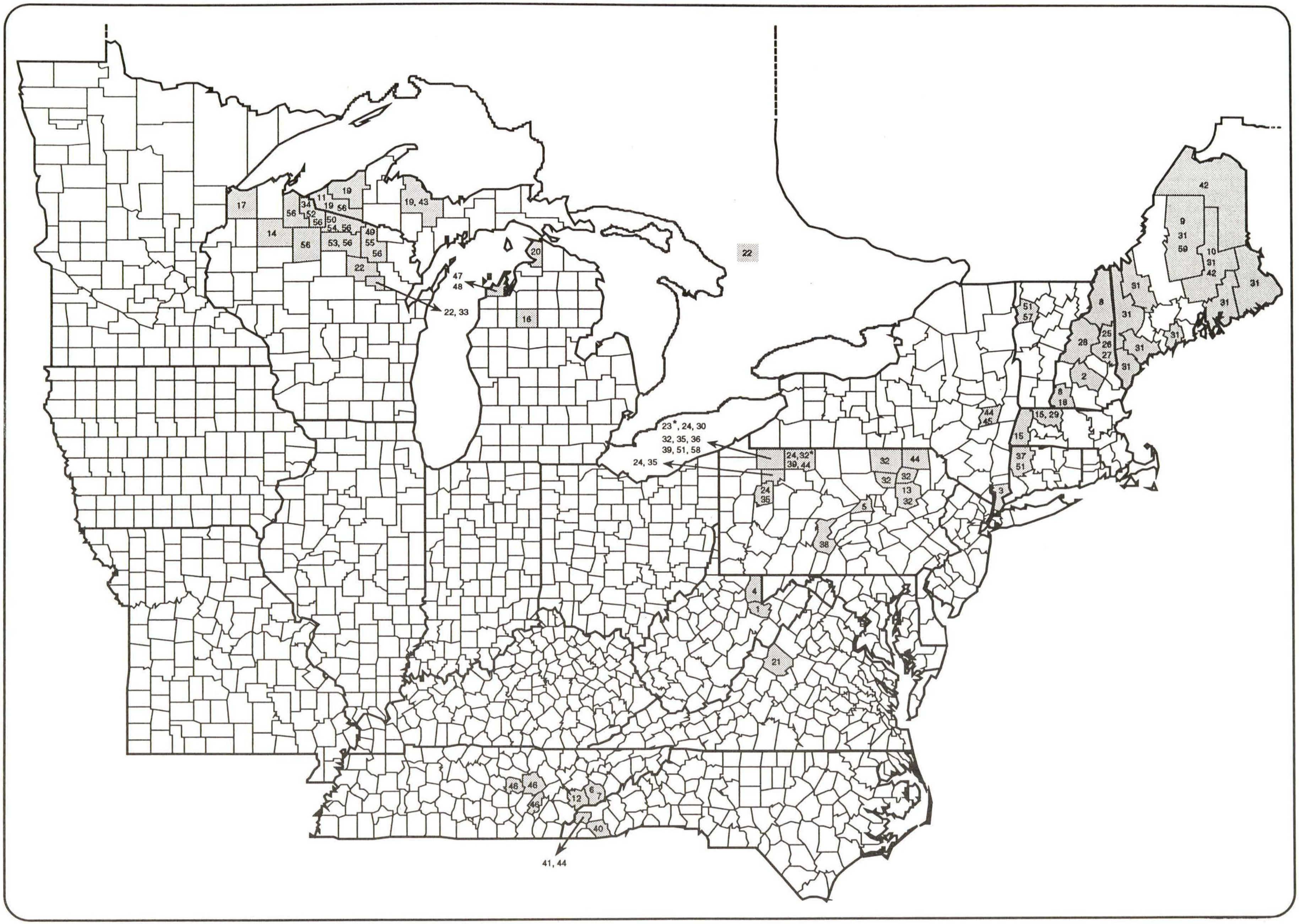

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Figure 9.—*General location of studies that provide stand structure information about old-growth conifer-northern hardwood forests. Shaded counties contain at least one study. Numbers correspond to the cited references listed under Map Key below and in Tables 57 through 66. States are indicated using two-letter postal abbreviations. An asterisk indicates that the county is probable, but not certain. The latitude and longitude of the Canadian study site were provided by the authors in the cited study and were used to plot the location of the shaded block on the map.*

Map Key	Source/Date	State or Province	County
1	Allard and Leonard 1952	WV	Tucker
2	Baldwin 1951	NH	Merrimack
3	Bard 1967	NY	Westchester
4	Bieri and Anliot 1965	WV	Preston
5	Boone 1983	PA	Union
6	Busing 1989	TN	Sevier
7	Busing and White 1993	TN	Sevier
8	Carbonneau 1986a	NH	Coos, Cheshire
9	Cogbill 1985	ME	Piscataquis
10	Conkling 1978	ME	Penobscot
11	Dahir and Lorimer 1996	MI	Gogebic
12	DeYoung 1979	TN	Blount
13	Donahue 1954	PA	Luzerne
14	Dunn et al 1983	WI	Sawyer
15	Dunwiddie 1993	MA	Berkshire, Franklin
16	Elliott 1953	MI	Missaukee
17	Fassett 1944	WI	Douglas
18	Foster 1988	NH	Cheshire
19	Frelich and Lorimer 1991	MI	Gogebic, Marquette, Ontonagon
20	Gates and Nichols 1930	MI	Emmet
21	Halpin 1990	VA	Augusta
22	Hett and Loucks 1976	WI Ontario	Langlade, Menominee 45°10'N, 78°45'W, 45°10'N, 88°55'W
23	Hough 1936	PA	Warren*
24	Hough and Forbes 1943	PA	Clarion, Forest, McKean, Warren
25	Leak 1985a	NH	Carroll
26	Leak 1987a	NH	Carroll
27	Leak 1987b	NH	Carroll
28	Leak and Graber 1974	NH	Grafton
29	Leverett 1988	MA	Franklin
30	Lutz 1930c	PA	Warren
31	Maine Critical Areas Program 1983b	ME	Cumberland, Franklin, Hancock, Lincoln, Oxford, Penobscot, Piscataquis, York Washington
32	Meyer and Stevenson 1943	PA	Bradford, Luzerne, McKean, Sullivan, Warren, Wyoming
33	Milfred et al. 1967	WI	Menominee
34	Mladenoff and Howell 1980	WI	Iron
35	Morey 1936a	PA	Clarion, Forest, Warren
36	Morey 1936b	PA	Warren
37	Nichols 1913	CT	Litchfield
38	Nowacki and Abrams 1994	PA	Huntingdon
39	Nowak 1993	PA	McKean, Warren
40	Oosting and Billings 1939	NC	Macon
41	Oosting and Bourdeau 1955	NC	Graham
42	Pinette and Rowe 1987	ME	Aroostook, Penobscot
43	Pregitzer and Barnes 1984	MI	Marquette
44	Runkle 1982	NY	Albany, Graham, McKean, Susquehanna
45	Runkle 1991	NY	Albany
46	Schmalzer 1978	TN	Rhea, Cumberland, White
47	Scott 1984	MI	Leelanau
48	Scott and Murphy 1986	MI	Leelanau
49	Stearns 1949	WI	Forest
50	Stearns 1950	WI	Vilas
51	Tritton and Siccama 1990	CT PA VT	Litchfield Warren Chittenden
52	Tyrrell 1988a	WI	Iron
53	Tyrrell 1988b	WI	Oneida
54	Tyrrell 1988c	WI	Vilas
55	Tyrrell 1989	WI	Forest
56	Tyrrell and Crow 1994	WI MI	Ashland, Forest, Iron, Oneida, Price, Vilas Gogebic
57	Vogelmann et al. 1985	VT	Chittenden
58	Whitney 1984	PA	Warren
59	Widoff 1985	ME	Piscataquis

Table 57.—*Location, size, and elevation of conifer-northern hardwood old-growth study sites. An asterisk indicates that the county information is likely, but not certain, based on information in the cited source.*

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
1	Allard and Leonard 1952	Cabin Mountain	WV	Tucker	unspecified	>991m
2	Baldwin 1951	Bradford	NH	Merrimack	0.8	207
3	Bard 1967	Mianus River Preserve--Gorge	NY	Westchester	}148[1]	76
3	Bard 1967	Mianus River Preserve--Ridge	NY	Westchester	}	152
4	Bieri and Anliot 1965	Cathedral State Park	WV	Preston	53	750-800
5	Boone 1983	Henstep Valley--Upper Section	PA	Union	upper river valley	544-600
6	Busing 1989	Long Branch Cove--Upper Stand-1930's	TN	Sevier	upper cove	950
6	Busing 1989	Long Branch Cove--Upper Stand-1980's	TN	Sevier	upper cove	950
7	Busing and White 1993	Roaring Fork	TN	Sevier	watershed	960-1137
8	Carbonneau 1986a	HM-1 (Gibbs Brook)	NH	Coos	4	670-700
8	Carbonneau 1986a	HM-2 (Williams)	NH	Cheshire	2	410
9	Cogbill 1985	Big Reed Pond Reserve--Mixed Forest	ME	Piscataquis	643[2]	364-578
10	Conkling 1978	Corrina	ME	Penobscot	1.6	unspecified
11	Dahir and Lorimer 1996	Porcupine Mountains--Presque Isle River	MI	Gogebic	}14,000[3]	}182-600[3]
11	Dahir and Lorimer 1996	Porcupine Mountains--Speakers Creek	MI	Gogebic	}	}
12	DeYoung 1979	Great Smoky Mtns--White Pine-Red Oak	TN	Blount	unspecified	450-671
12	DeYoung 1979	Great Smoky Mtns--White Pine-White Oak	TN	Blount	unspecified	312-663
13	Donahue 1954	Bear Creek Ravine--No Pine	PA	Luzerne	unspecified	1560-1600
13	Donahue 1954	Bear Creek Ravine--With Pine	PA	Luzerne	unspecified	1500
14	Dunn et al 1983	Flambeau River	WI	Sawyer	61	unspecified
15	Dunwiddie 1993	Bash Bish--A-Grinder Brook	MA	Berkshire	7	421-442
15	Dunwiddie 1993	Bash Bish--B-Bash Bish Falls	MA	Berkshire	6	367
15	Dunwiddie 1993	Cold River--A-Plots 2, 3, 4	MA	Franklin	8	396-457
15	Dunwiddie 1993	Cold River--B-Black Brook	MA	Franklin	4.5	384-396
15	Dunwiddie 1993	Cold River--D	MA	Franklin	28	381
15	Dunwiddie 1993	Cold River--E-Manning Brook-Plot 1	MA	Franklin	5	440
15	Dunwiddie 1993	Dunbar Brook--Plot 2	MA	Berkshire	11	468
15	Dunwiddie 1993	Fife Brook--Plots 3, 4	MA	Berkshire	10	369-378
15	Dunwiddie 1993	Mt. Everett--Glen Brook	MA	Berkshire	10	502
15	Dunwiddie 1993	Mt. Greylock--Deer Hill	MA	Berkshire	12	611
15	Dunwiddie 1993	Mt. Greylock--Money Brook-Plot 3	MA	Berkshire	9	659
15	Dunwiddie 1993	Parsonage Brook	MA	Franklin	4.2	494
16	Elliott 1953	Missaukee	MI	Missaukee	county	unspecified
17	Fassett 1944	Brule River Basin	WI	Douglas	watershed	unspecified
18	Foster 1988	Harvard Tract	NH	Cheshire	10	unspecified
19	Frelich and Lorimer 1991	Huron Mountains	MI	Marquette	2500	unspecified
19	Frelich and Lorimer 1991	Porcupine Mountains	MI	Gogebic, Ontonagon	14500	unspecified

(Table 57 continued on next page)

(Table 57 continued)

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
19	Frelich and Lorimer 1991	Sylvania	MI	Gogebic	6000	unspecified
19	Frelich and Lorimer 1991	23 stands in Upper Michigan	MI	Gogebic, Ontonagon	various	various
20	Gates and Nichols 1930	Pellston	MI	Emmet	32 + 24	unspecified
21	Halpin 1990	Ramsey's Draft--Quad 1	VA	Augusta	}115[4]	}609-1280
21	Halpin 1990	Ramsey's Draft--Quad 2	VA	Augusta	}	}
21	Halpin 1990	Ramsey's Draft--Quad 3	VA	Augusta	}	}
21	Halpin 1990	Ramsey's Draft--Quads 1-3	VA	Augusta	}	}
22	Hett and Loucks 1976	Gardner Dam	WI	Langlade	unspecified	unspecified
22	Hett and Loucks 1976	Northwest Lake	Ontario	45°10'N, 78°45'W	unspecified	unspecified
22	Hett and Loucks 1976	Pot Lake	Ontario	45°10'N, 78°45'W	unspecified	unspecified
22	Hett and Loucks 1976	West Branch	WI	Menominee	unspecified	unspecified
23	Hough 1936	East Tionesta	PA	Warren*	485	1800-2400
24	Hough and Forbes 1943	Cook Forest	PA	Clarion, Forest	unspecified	unspecified
24	Hough and Forbes 1943	East Tionesta Creek Valley	PA	Warren, McKean	unspecified	429-591
24	Hough and Forbes 1943	Stand Near Hearts Content	PA	Warren	unspecified	upper slopes
25	Leak 1985a	Bartlett Ridge	NH	Carroll	~8	457
25	Leak 1985a	Bartlett 19	NH	Carroll	~8	305
25	Leak 1985a	Bartlett 26	NH	Carroll	unspecified	unspecified
26	Leak 1987a	Bartlett Ridge	NH	Carroll	~8	457
26	Leak 1987a	Bartlett 19	NH	Carroll	~8	305
27	Leak 1987b	Bartlett--bedrock	NH	Carroll	}1050[5]	400-650
27	Leak 1987b	Bartlett--dry compact till	NH	Carroll	}	300-600
27	Leak 1987b	Bartlett--outwash	NH	Carroll	}	425-475
27	Leak 1987b	Bartlett--wet compact till	NH	Carroll	}	300
28	Leak and Graber 1974	Mt. Whiteface (The Bowl)	NH	Grafton	mountain slope	700-900
29	Leverett 1988	Dunbar Brook	MA	Franklin	unspecified	unspecified
30	Lutz 1930c	Hearts Content--Hemlock	PA	Warren	}49[6]	}549[6]
30	Lutz 1930c	Hearts Content--Hemlock-Beech	PA	Warren	}	}
31	Maine Critical Areas Program 1983b	Adams Pond Hemlock	ME	Cumberland	2	195
31	Maine Critical Areas Program 1983b	Bald Mountain	ME	Washington	0.4	91
31	Maine Critical Areas Program 1983b	Chesuncook Lake	ME	Piscataquis	18	323
31	Maine Critical Areas Program 1983b	Farm Cove Mountain Hemlock	ME	Washington	2	137
31	Maine Critical Areas Program 1983b	Hollis White Pine - Hemlock	ME	York	5	61
31	Maine Critical Areas Program 1983b	Huston Brook	ME	Franklin	unspecified	323
31	Maine Critical Areas Program 1983b	Mattawamkeag River Hemlock	ME	Penobscot	2	85
31	Maine Critical Areas Program 1983b	Moosehorn Stream	ME	Piscataquis	10	372
31	Maine Critical Areas Program 1983b	Mt. Christopher Hemlock	ME	Oxford	1.2	335-366

(Table 57 continued on next page)

(Table 57 continued)

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
31	Maine Critical Areas Program 1983b	Newcastle	ME	Lincoln	2.4	6
31	Maine Critical Areas Program 1983b	No. 3 Pond Hemlock	ME	Penobscot	11	91
31	Maine Critical Areas Program 1983b	Ocean Park White Pine - Hemlock	ME	York	3.2	6
31	Maine Critical Areas Program 1983b	Pine Stream Flowage	ME	Piscataquis	20	305
31	Maine Critical Areas Program 1983b	Pleasant Lake Hemlock	ME	Washington	20	119
31	Maine Critical Areas Program 1983b	Prentiss Woods White Pine- Hemlock	ME	Penobscot	12	61
31	Maine Critical Areas Program 1983b	Sabao Lake Hemlock	ME	Hancock	6	152
31	Maine Critical Areas Program 1983b	Thomas Point Hemlock	ME	Lincoln	2	15
31	Maine Critical Areas Program 1983b	Waldoboro Hemlock	ME	Lincoln	2	82
31	Maine Critical Areas Program 1983b	Wassataquoik Stream White Pine	ME	Penobscot	6	152
32	Meyer and Stevenson 1943	Dunham--Stands 13-16	PA	Warren	43	unspecified
32	Meyer and Stevenson 1943	Larson--Stands 11-12	PA	Warren	17	unspecified
32	Meyer and Stevenson 1943	McClure--Stand 1	PA	Bradford	12	unspecified
32	Meyer and Stevenson 1943	Ricketts--Stands 4-5	PA	Luzerne, Wyoming	6	unspecified
32	Meyer and Stevenson 1943	Rightmeier--Stands 6-10	PA	Sullivan	21	unspecified
32	Meyer and Stevenson 1943	Tionesta--Stands 17-26	PA	McKean*	59	unspecified
33	Milfred et al. 1967	Stand 10	WI	Menominee	0.4-0.8	}190-434 [7]
33	Milfred et al. 1967	Stand 27	WI	Menominee	0.4-0.8	}
33	Milfred et al. 1967	Stand 35	WI	Menominee	0.4-0.8	}
34	Mladenoff and Howell 1980	Gogebic Range	WI	Iron	north part of county	335-580
35	Morey 1936a	Cook Forest	PA	Clarion, Forest	61	1400
35	Morey 1936a	Hearts Content--Beech-Hemlock	PA	Warren	}49 [6]	}549 [6]
35	Morey 1936a	Hearts Content--Hemlock	PA	Warren	}	}
36	Morey 1936b	Hearts Content	PA	Warren	49	549
37	Nichols 1913	Colebrook Forest	CT	Litchfield	121	unspecified
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 1	PA	Huntingdon	}148 [8]	302
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 2	PA	Huntingdon	}	302
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 3	PA	Huntingdon	}	302
38	Nowacki and Abrams 1994	Alan Seeger--Stream Terrace 1	PA	Huntingdon	}	303
38	Nowacki and Abrams 1994	Alan Seeger--Stream Terrace 2	PA	Huntingdon	}	303
39	Nowak 1993	Tionesta--RNAOG1	PA	McKean	80+	520-550
39	Nowak 1993	Tionesta--RNAOG2	PA	McKean, Warren	40	~580
39	Nowak 1993	Tionesta--RNAOG3	PA	McKean	18	580
40	Oosting and Billings 1939	Ravenel's Woods--Polycodium type	NC	Macon	}400 [9]	}1341 [9]
40	Oosting and Billings 1939	Ravenel's Woods--Rhododendron type	NC	Macon	}	}
41	Oosting and Bourdeau 1955	Joyce Kilmer--Forest-Herb Type	NC	Graham	}1539 [10]	}760-1585 [10]
41	Oosting and Bourdeau 1955	Joyce Kilmer--Forest-Rhododendron Type	NC	Graham	}	}

(Table 57 continued on next page)

(Table 57 continued)

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
42	Pinette and Rowe 1987	East Pinnacles	ME	Aroostook	10	243-274
42	Pinette and Rowe 1987	Scraggly Lake	ME	Penobscot	26	243-335
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 3	MI	Marquette	121	low plateau
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 6	MI	Marquette	50	upper slope
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 8	MI	Marquette	195	midslope
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 10	MI	Marquette	24	rocky ridgetop
44	Runkle 1982	Huyck Preserve	NY	Albany	unspecified	unspecified
44	Runkle 1982	Joyce Kilmer Wilderness Area	NC	Graham	unspecified	unspecified
44	Runkle 1982	Tionesta Scenic and Research Natural Areas	PA	McKean	unspecified	unspecified
44	Runkle 1982	Woodbourne Forest and Wildlife Sanctuary	PA	Susquehanna	unspecified	unspecified
45	Runkle 1991	Huyck Preserve--1978	NY	Albany	unspecified	unspecified
45	Runkle 1991	Huyck Preserve--1986	NY	Albany	unspecified	unspecified
46	Schmalzer 1978	Doe Creek, Little Piney Creek, Obed River	TN	Cumberland, Rhea, White	unspecified	416
47	Scott 1984	South Manitou Island	MI	Leelanau	20	176[11]
48	Scott and Murphy 1986	South Manitou Island	MI	Leelanau	20	176[11]
49	Stearns 1949	T35N, R14E, Sections 18,30	WI	Forest	unspecified	473
50	Stearns 1950	Gillen Refuge	WI	Vilas	0.4	unspecified
51	Tritton and Siccama 1990	Catlin Wood	CT	Litchfield	unspecified	unspecified
51	Tritton and Siccama 1990	Eastwoods	VT	Chittenden	unspecified	unspecified
51	Tritton and Siccama 1990	Heart's Content	PA	Warren	unspecified	unspecified
52	Tyrrell 1988a	Moose Lake Hemlocks	WI	Iron	9	503
53	Tyrrell 1988b	Patterson Hemlocks	WI	Oneida	77	488
54	Tyrrell 1988c	Plum Lake Hemlocks	WI	Vilas	92	518
55	Tyrrell 1989	Scott Lake - Shelp Lake	WI	Forest	19	503
56	Tyrrell and Crow 1994	Argonne	WI	Forest	16	unspecified
56	Tyrrell and Crow 1994	Escanaba	WI	Vilas	6	unspecified
56	Tyrrell and Crow 1994	Glimmerglass	MI	Gogebic	6	unspecified
56	Tyrrell and Crow 1994	Helen	MI	Gogebic	7	unspecified
56	Tyrrell and Crow 1994	High	WI	Oneida	1	unspecified
56	Tyrrell and Crow 1994	Holmboe	WI	Oneida	7	unspecified
56	Tyrrell and Crow 1994	Island	WI	Iron	4	unspecified
56	Tyrrell and Crow 1994	Keego	WI	Vilas	3	unspecified
56	Tyrrell and Crow 1994	Kemp	WI	Oneida	19	unspecified
56	Tyrrell and Crow 1994	Laura	WI	Vilas	10	unspecified
56	Tyrrell and Crow 1994	Lois	MI	Gogebic	15	unspecified
56	Tyrrell and Crow 1994	Memorial Grove	WI	Price	19	unspecified
56	Tyrrell and Crow 1994	Moose	WI	Iron	8	unspecified

(Table 57 continued on next page)

(Table 57 continued)

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
56	Tyrrell and Crow 1994	One Stone	WI	Oneida	13	unspecified
56	Tyrrell and Crow 1994	Outer Island	WI	Ashland	41	unspecified
56	Tyrrell and Crow 1994	Patterson	WI	Oneida	10	unspecified
56	Tyrrell and Crow 1994	Plum	WI	Vilas	101	unspecified
56	Tyrrell and Crow 1994	Popple	WI	Forest	4	unspecified
56	Tyrrell and Crow 1994	Pukall	WI	Vilas	10	unspecified
56	Tyrrell and Crow 1994	Salsich	WI	Vilas	9	unspecified
56	Tyrrell and Crow 1994	Scott	WI	Forest	8	unspecified
56	Tyrrell and Crow 1994	Sweeny	WI	Oneida	13	unspecified
56	Tyrrell and Crow 1994	Tucker	WI	Price	16	unspecified
56	Tyrrell and Crow 1994	Wabikon	WI	Forest	3	unspecified
56	Tyrrell and Crow 1994	Woodland	WI	Oneida	3	unspecified
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1965	VT	Chittenden	western slope	730-850
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1979	VT	Chittenden	western slope	730-850
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1983	VT	Chittenden	western slope	730-850
58	Whitney 1984	Hearts Content--Hemlock-1929	PA	Warren	}49[7]	}549[7]
58	Whitney 1984	Hearts Content--Hemlock-1978	PA	Warren	}	}
58	Whitney 1984	Hearts Content--Hemlock-Beech-1929	PA	Warren	}	}
58	Whitney 1984	Hearts Content--Hemlock-Beech-1978	PA	Warren	}	}
59	Widoff 1985	Big Reed Pond Reserve--Mixed Forest	ME	Piscataquis	2025	364-578

[1] Mianus River Preserve is 148 ha; unspecified how extensive gorge and ridge areas are.

[2] Area is for the mixed forest part of the Big Reed Pond Reserve.

[3] Area and elevation range for entire Porcupine Mountains.

[4] Area of the entire Ramsey's Draft.

[5] Area of the entire Bartlett Experiment Forest.

[6] Area and elevation estimate for Hearts Content.

[7] Elevation range within the county.

[8] Area of entire Alan Seeger natural area is 148 ha; virgin stand of hemlock-white pine-hardwoods is 10 ha; unspecified area of stream bottom versus stream terrace.

[9] Area and estimate of elevation for Ravenel's Woods.

[10] Area and elevation range for Joyce Kilmer area.

[11] Elevation of Lake Michigan.

Table 58.—*Criteria used by sources to identify old-growth stands, and information about stand composition of conifer-northern hardwood old-growth study sties. Conifers present in the stands are: H, eastern hemlock; RS, red spruce; WP, eastern white pine; and WC, northern white-cedar.*

Map Key	Source/Date	Stand	Conifer Type	Criteria for Stand Selection and Stand Composition
1	Allard and Leonard 1952	Cabin Mountain	RS	Presettlement reconstruction of red spruce-hardwoods
2	Baldwin 1951	Bradford	WP-H	150-200 yr old stand; survived hurricane undisturbed; white pine-hemlock
3	Bard 1967	Mianus River Preserve--Gorge	H	Old mature forest; part of gorge undisturbed; hemlock (51% by density)-hardwoods
3	Bard 1967	Mianus River Preserve--Ridge	H	Old mature forest; hemlock (44% by density)-hardwoods
4	Bieri and Anliot 1965	Cathedral State Park	H	Uncut, virgin hemlock forest; hemlock (63% by basal area)
5	Boone 1983	Henstep Valley--Upper Section	H	Not lumbered for past 80 years; hemlock (27% by basal area)-yellow birch-red maple)
6	Busing 1989	Long Branch Cove--Upper Stand-1930's	H[1]	Primeval; mesic hemlock (19% by basal area)-deciduous forest
6	Busing 1989	Long Branch Cove--Upper Stand-1980's	H[1]	Primeval; mesic hemlock (19% by basal area[2])-deciduous forest
7	Busing and White 1993	Roaring Fork	H[1]	Old growth; no history of logging or catastrophic natural disturbance; hemlock cove forest
8	Carbonneau 1986a	HM-1 (Gibbs Brook)	H	Oldest trees >200-250 yr; hemlock
8	Carbonneau 1986a	HM-2 (Williams)	H	Oldest trees >200-250 yr; hemlock
9	Cogbill 1985	Big Reed Pond Reserve--Mixed Forest	RS	Never logged; red spruce (34%)-sugar maple (27%)-beech (13%) by basal area
10	Conkling 1978	Corrina	WP-H	Minimum 100 yr, >0.04 ha, minimal disturbance; white pine (>75%)-hemlock-red maple
11	Dahir and Lorimer 1996	Porcupine Mountains--Presque Isle River	H	Old growth (see Frelich and Lorimer 1991); hemlock (57%)-sugar maple (15%)
11	Dahir and Lorimer 1996	Porcupine Mountains--Speakers Creek	H	Old growth (see Frelich and Lorimer 1991); hemlock (66%)-sugar maple (16%)
12	DeYoung 1979	Great Smoky Mtns--White Pine-Red Oak	WP	Limited human disturbance; white pine-white oak
12	DeYoung 1979	Great Smoky Mtns--White Pine-White Oak	WP	Limited human disturbance; white pine-red oak
13	Donahue 1954	Bear Creek Ravine--No Pine	H	Remnant primary stands of hemlock (70% by basal area)-beech
13	Donahue 1954	Bear Creek Ravine--With Pine	WP-H	Remnant primary stands of hemlock (19%)-beech-white pine (53%)--% by basal area
14	Dunn et al 1983	Flambeau River	H	Pre-blowdown virgin tract; hemlock (63% by basal area)-yellow birch-sugar maple
15	Dunwiddie 1993	Bash Bish--A-Grinder Brook	H	Met criteria of stand size, age, disturbance; uncut; hemlock (80%)-yellow birch (14%)
15	Dunwiddie 1993	Bash Bish--B-Bash Bish Falls	H	Met criteria of stand size, age, disturbance; uncut; hemlock (77%)
15	Dunwiddie 1993	Cold River--A-Plots 2, 3, 4	H	Met criteria of stand size, age, disturbance; uncut; hemlock (51%)-hardwoods
15	Dunwiddie 1993	Cold River--B-Black Brook	H	Met criteria of stand size, age, disturbance; uncut; hemlock (44%)-beech (32%)
15	Dunwiddie 1993	Cold River--D	H	Met criteria of stand size, age, disturbance; uncut; hemlock (54%)-hardwoods
15	Dunwiddie 1993	Cold River--E-Manning Brook-Plot 1	H	Met criteria of stand size, age, disturbance; uncut; hemlock (48%)-sugar maple (50%)
15	Dunwiddie 1993	Dunbar Brook--Plot 2	H	Met criteria of stand size, age, disturbance; uncut; hemlock (37%)-hardwoods
15	Dunwiddie 1993	Fife Brook--Plots 3, 4	H	Met criteria of stand size, age, disturbance; uncut; hemlock (41%)-beech (34%)
15	Dunwiddie 1993	Mt. Everett--Glen Brook	H	Met criteria of stand size, age, disturbance; uncut; hemlock (72%)
15	Dunwiddie 1993	Mt. Greylock--Deer Hill	H	Met criteria of stand size, age, disturbance; uncut; hemlock (76%)
15	Dunwiddie 1993	Mt. Greylock--Money Brook-Plot 3	H	Met criteria of stand size, age, disturbance; uncut; hemlock (34%)-yellow birch (47%)
15	Dunwiddie 1993	Parsonage Brook	H	Met criteria of stand size, age, disturbance; uncut; hemlock (67%)
16	Elliott 1953	Missaukee	H	Original land survey; hemlock (23% by density)-white pine (11%)-hardwoods
17	Fassett 1944	Brule River Basin	WP	Original land survey; white pine-hardwoods
18	Foster 1988	Harvard Tract	WP-H	Formerly old-growth transition hardwood-white pine-hemlock
19	Frelich and Lorimer 1991	Huron Mountains	H	Criteria based on percentage crown area in large versus mature trees[3]
19	Frelich and Lorimer 1991	Porcupine Mountains	H	Criteria based on percentage crown area in large versus mature trees[3]

(Table 58 continued on next page)

(Table 58 continued)

Map Key	Source/Date	Stand	Conifer Type	Criteria for Stand Selection and Stand Composition
19	Frelich and Lorimer 1991	Sylvania	H	Criteria based on percentage crown area in large versus mature trees[3]
19	Frelich and Lorimer 1991	23 stands in Upper Michigan	H	Criteria use crown area in large versus mature trees[3]; stands > 30% hemlock by basal area[4]
20	Gates and Nichols 1930	Pellston	H	Primeval; beech-maple-hemlock
21	Halpin 1990	Ramsey's Draft--Quad 1	H	Virgin, old growth; hemlock-hardwoods
21	Halpin 1990	Ramsey's Draft--Quad 2	H[1]	Virgin, old growth; hemlock-hardwoods
21	Halpin 1990	Ramsey's Draft--Quad 3	H[1]	Virgin, old growth; hemlock-hardwoods
21	Halpin 1990	Ramsey's Draft--Quads 1-3	H	Virgin, old growth; hemlock-hardwoods
22	Hett and Loucks 1976	Gardner Dam	H-WP	Mature; hemlock-yellow birch-white pine
22	Hett and Loucks 1976	Northwest Lake	H	Mature; hemlock
22	Hett and Loucks 1976	Pot Lake	H	Mature; hemlock-hardwoods
22	Hett and Loucks 1976	West Branch	H	Mature; hemlock
23	Hough 1936	East Tionesta	H-WP	Virgin
24	Hough and Forbes 1943	Cook Forest	H-WP	Most white pine originated after drought and fire in 1644
24	Hough and Forbes 1943	East Tionesta Creek Valley	H-WP	Virgin stand; hemlock (61%)-beech (22%)-white pine
24	Hough and Forbes 1943	Stand Near Hearts Content	H-WP	Formerly virgin white pine-hemlock-hardwood stand
25	Leak 1985a	Bartlett Ridge	H-RS	Overmature; never cut or lightly cut; hemlock-red spruce
25	Leak 1985a	Bartlett 19	H-RS	Overmature; never cut or lightly cut; hemlock-red spruce
25	Leak 1985a	Bartlett 26	H	Mixed wood old growth; high-graded in late 1800's; hemlock-red maple
26	Leak 1987a	Bartlett Ridge	H-RS	Overmature; never cut or lightly cut; hemlock-red spruce
26	Leak 1987a	Bartlett 19	H-RS	Overmature; never cut or lightly cut; hemlock-red spruce
27	Leak 1987b	Bartlett--bedrock	RS-H	Lightly cut before ~1890; red spruce-hemlock
27	Leak 1987b	Bartlett--dry compact till	H-RS	Lightly cut before ~1890; hemlock-red spruce
27	Leak 1987b	Bartlett--outwash	RS-H	Lightly cut before ~1890; hemlock-red spruce
27	Leak 1987b	Bartlett--wet compact till	H-RS	Lightly cut before ~1890; hemlock-red spruce
28	Leak and Graber 1974	Mt. Whiteface (The Bowl)	RS[5]	Never logged; area of red spruce-yellow birch at 700-900 m elevation
29	Leverett 1988	Dunbar Brook	H	Large trees, seemed old growth
30	Lutz 1930c	Hearts Content--Hemlock	H-WP	Virgin; hemlock (82%)-white pine (6%) trees over 25 cm d.b.h.
30	Lutz 1930c	Hearts Content--Hemlock-Beech	H-WP	Virgin; salvage white pine cut 1911; hemlock (36%)-beech (24%)-white pine (11%)
31	Maine Critical Areas Program 1983b	Adams Pond Hemlock	H-RS	Several criteria used (e.g., age, naturalness); hemlock (80%)-beech-yellow birch-red spruce
31	Maine Critical Areas Program 1983b	Bald Mountain	WP-RS	Several criteria used; overstory white pine; red spruce-balsam fir-maple
31	Maine Critical Areas Program 1983b	Chesuncook Lake	RS-WP	Several criteria used; remains of stumps; red spruce-balsam fir-white pine
31	Maine Critical Areas Program 1983b	Farm Cove Mountain Hemlock	H-RS	Several criteria used (e.g., age, naturalness); hemlock-red spruce-beech-yellow birch
31	Maine Critical Areas Program 1983b	Hollis White Pine - Hemlock	WP-H	Several criteria used; a few dead trees removed; white pine-hemlock
31	Maine Critical Areas Program 1983b	Huston Brook	WC-RS-WP	Several criteria used; white-cedar-sugar maple-yellow birch-red spruce-hemlock-white pine
31	Maine Critical Areas Program 1983b	Mattawamkeag River Hemlock	H	Several criteria used (e.g., age, naturalness); uncut; hemlock (>80%)-red spruce
31	Maine Critical Areas Program 1983b	Moosehorn Stream	WP-RS	Several criteria used; selection cut ~80 yr ago; overstory white pine-red spruce
31	Maine Critical Areas Program 1983b	Mt. Christopher Hemlock	H-WP	Several criteria used (e.g., age, naturalness); fire origin; hemlock-white pine-white birch

(Table 58 continued on next page)

(Table 58 continued)

Map Key	Source/Date	Stand	Conifer Type	Criteria for Stand Selection and Stand Composition
31	Maine Critical Areas Program 1983b	Newcastle	WP	Several criteria used (e.g., age, naturalness); white pine-red oak
31	Maine Critical Areas Program 1983b	No. 3 Pond Hemlock	H	Several criteria used (e.g., age, naturalness); scattered stumps; hemlock (>80%)
31	Maine Critical Areas Program 1983b	Ocean Park White Pine - Hemlock	WP-H	Several criteria used; some cutting of dead trees, use as nature area
31	Maine Critical Areas Program 1983b	Pine Stream Flowage	RS-WP	Several criteria used; selectively cut decades ago; red spruce-balsam fir-white pine
31	Maine Critical Areas Program 1983b	Pleasant Lake Hemlock	H-WP-RS	Several criteria used (e.g., age, naturalness); burned in the past, relatively undisturbed
31	Maine Critical Areas Program 1983b	Prentiss Woods White Pine- Hemlock	WP-H	Several criteria used; removal of a few white pine in 1960's; white pine-hemlock
31	Maine Critical Areas Program 1983b	Sabao Lake Hemlock	H-RS	Several criteria used;relatively undisturbed, some hurricane damage
31	Maine Critical Areas Program 1983b	Thomas Point Hemlock	H-WP-RS	Several criteria used; possibly undisturbed; hemlock-white pine-red spruce
31	Maine Critical Areas Program 1983b	Waldoboro Hemlock	H	Several criteria used (e.g., age, naturalness); uncut; hemlock-yellow birch-red maple
31	Maine Critical Areas Program 1983b	Wassataquoik Stream White Pine	WP	Several criteria used; many pines cut in '50's; white pine (older)-beech-sugar maple
32	Meyer and Stevenson 1943	Dunham--Stands 13-16	H	Virgin; hemlock (32-54% by density)-beech-birch-maple
32	Meyer and Stevenson 1943	Larson--Stands 11-12	H	Virgin; hemlock (45-46% by density)-beech-birch-maple
32	Meyer and Stevenson 1943	McClure--Stand 1	H	Virgin; hemlock (11-20% by density)-beech-birch-maple
32	Meyer and Stevenson 1943	Ricketts--Stands 4-5	H	Virgin; hemlock (25-45% by density)-beech-birch-maple
32	Meyer and Stevenson 1943	Rightmeier--Stands 6-10	H	Virgin; hemlock (21-25% by density)-beech-birch-maple
32	Meyer and Stevenson 1943	Tionesta--Stands 17-26	H	Virgin; hemlock (24-50% by density)-beech-birch-maple
33	Milfred et al. 1967	Stand 10	WP-H	Mesic 130-yr forest; white pine-hemlock-hardwoods
33	Milfred et al. 1967	Stand 27	H	Forest in compositional equilibrium; hemlock-hardwoods
33	Milfred et al. 1967	Stand 35	WP-H	Mesic 130-yr forest; white pine-hemlock-hardwoods
34	Mladenoff and Howell 1980	Gogebic Range	H	Reconstruction of 1860's vegetation in areas formerly hemlock-sugar maple community
35	Morey 1936a	Cook Forest	H-WP	Approach virgin condition; scattered stumps, some dead trees removed; 51% hemlock
35	Morey 1936a	Hearts Content--Beech-Hemlock	H-WP	Scattered stumps, some dead trees removed; 36% hemlock >25 cm by density
35	Morey 1936a	Hearts Content--Hemlock	H-WP	Scattered stumps, some dead trees removed; 82% hemlock >25 cm by density
36	Morey 1936b	Hearts Content	H-WP	Virgin; hemlock-pine-hardwood forest
37	Nichols 1913	Colebrook Forest	H	Once-virgin timber; hemlock-beech (55% combined)
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 1	H	Reported old growth; relatively pristine appearance; hemlock-birch
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 2	H	Reported old growth; relatively pristine appearance; hemlock-birch
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 3	H	Reported old growth; relatively pristine appearance; hemlock-birch
38	Nowacki and Abrams 1994	Alan Seeger--Stream Terrace 1	H-WP	Reported old growth; relatively pristine appearance; hemlock-pine
38	Nowacki and Abrams 1994	Alan Seeger--Stream Terrace 2	H-WP	Reported old growth; relatively pristine appearance; hemlock-pine
39	Nowak 1993	Tionesta--RNAOG1	H	All-age old-growth structure; hemlocks 300-500 yr; hemlock (60%)[6]-beech
39	Nowak 1993	Tionesta--RNAOG2	H	All-age old-growth structure; hemlocks 300-500 yr; hemlock (40%)[6]-beech
39	Nowak 1993	Tionesta--RNAOG3	H	All-age old-growth structure; hemlocks 300-500 yr; hemlock (20%)[6]-beech
40	Oosting and Billings 1939	Ravenel's Woods--Polycodium type	H	Not burned, grazed, or cut; hemlock-yellow birch-red oak-chestnut
40	Oosting and Billings 1939	Ravenel's Woods--Rhododendron type	H[1]	Not burned, grazed, or cut; hemlock-mixed forest
41	Oosting and Bourdeau 1955	Joyce Kilmer--Forest-Herb Type	H[1]	Virgin; hemlock (21-61%[7] by basal area > 2.5 cm)
41	Oosting and Bourdeau 1955	Joyce Kilmer--Forest-Rhododendron Type	H[1]	Virgin; hemlock (18-72%[8] by basal area > 2.5 cm)

(Table 58 continued on next page)

(Table 58 continued)

Map Key	Source/Date	Stand	Conifer Type	Criteria for Stand Selection and Stand Composition
42	Pinette and Rowe 1987	East Pinnacles	H	>100 yr; identity undisturbed
42	Pinette and Rowe 1987	Scraggly Lake	H	>100 yr; identity undisturbed
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 3	H	Some pine removed <1930; hemlock (22%) [9]
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 6	WP [10]	Some pine removed <1930; white pine (65%)-hardwoods (15%)
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 8	H-WP	Some pine removed <1930; 26% conifers (white pine, balsam fir, white spruce, hemlock) [11]
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 10	WP	Some pine removed <1930; 38% conifer (white pine, balsam fir, white spruce)
44	Runkle 1982	Huyck Preserve	H	Without obvious large-scale disturbance; beech-hemlock
44	Runkle 1982	Joyce Kilmer Wilderness Area	H [1]	Without obvious large-scale disturbance; sugar maple-beech-silverbell-basswood-hemlock
44	Runkle 1982	Tionesta Scenic and Research Natural Areas	H	Without obvious large-scale disturbance; beech-hemlock (20%), see Runkle 1981
44	Runkle 1982	Woodbourne Forest and Wildlife Sanctuary	H	Without obvious large-scale disturbance; sugar maple-ash-hemlock
45	Runkle 1991	Huyck Preserve--1978	H	Originated after clearcutting in 1800; beech-hemlock
45	Runkle 1991	Huyck Preserve--1986	H	Originated after clearcutting in 1800; beech-hemlock
46	Schmalzer 1978	Doe Creek, Little Piney Creek, Obed River	H [1]	No logging, grazing, fire in last 40+ yr; hemlock (43% by basal area)
47	Scott 1984	South Manitou Island	WC	Unlogged; upland northern white-cedar (73% by basal area)-hardwoods
48	Scott and Murphy 1986	South Manitou Island	WC	Unlogged; upland northern white-cedar (73% by basal area)-hardwoods
49	Stearns 1949	T35N, R14E, Sections 18,30	H	Residual; undisturbed; hardwood-conifer stands (34% hemlock by density >17.8 cm)
50	Stearns 1950	Gillen Refuge	WP-H	White pine-white birch-hemlock (74% conifers by density) >54 cm [12]
51	Tritton and Siccama 1990	Catlin Wood	H	Stands >40 yr, most with 100-200 yr dominants; hemlock-yellow birch
51	Tritton and Siccama 1990	Eastwoods	H	Stands >40 yr, most with 100-200 yr dominants; hemlock-yellow birch
51	Tritton and Siccama 1990	Heart's Content	H	Stands >40 yr, most with 100-200 yr dominants; hemlock-yellow birch
52	Tyrrell 1988a	Moose Lake Hemlocks	H	Old-growth remnant; essentially uncut, occasional stumps; hemlock-yellow birch
53	Tyrrell 1988b	Patterson Hemlocks	H-WP	State significant hemlock-yellow birch-white pine forest, portions undisturbed
54	Tyrrell 1988c	Plum Lake Hemlocks	H	State significant, near virgin old-growth; hemlock-hardwoods
55	Tyrrell 1989	Scott Lake - Shelp Lake	H-WP	Remnant old growth; undisturbed; white pine-hemlock
56	Tyrrell and Crow 1994	Argonne	H	>175 years; few or no stumps; hemlock (61% by basal area)-white pine (5%)
56	Tyrrell and Crow 1994	Escanaba	H	>175 years; few or no stumps; hemlock (77% by basal area)
56	Tyrrell and Crow 1994	Glimmerglass	H	>175 years; few or no stumps; hemlock (78% by basal area)
56	Tyrrell and Crow 1994	Helen	H	>175 years; few or no stumps; hemlock (58% by basal area)
56	Tyrrell and Crow 1994	High	H	>175 years; few or no stumps; hemlock (64% by basal area)
56	Tyrrell and Crow 1994	Holmboe	H	>175 years; few or no stumps; hemlock (61% by basal area)-white pine (5%)
56	Tyrrell and Crow 1994	Island	H	>175 years; few or no stumps; hemlock (72% by basal area)
56	Tyrrell and Crow 1994	Keego	H	>175 years; few or no stumps; hemlock (67% by basal area)-white pine (5%)
56	Tyrrell and Crow 1994	Kemp	H	>175 years; few or no stumps; hemlock (68% by basal area)
56	Tyrrell and Crow 1994	Laura	H	>175 years; few or no stumps; hemlock (77% by basal area)
56	Tyrrell and Crow 1994	Lois	H	>175 years; few or no stumps; hemlock (58% by basal area)
56	Tyrrell and Crow 1994	Memorial Grove	H	>175 years; few or no stumps; hemlock (69% by basal area)
56	Tyrrell and Crow 1994	Moose	H	>175 years; few or no stumps; hemlock (60% by basal area)

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(Table 58 continued)

Map Key	Source/Date	Stand	Conifer Type	Criteria for Stand Selection and Stand Composition
56	Tyrrell and Crow 1994	One Stone	H	>175 years; few or no stumps; hemlock (81% by basal area)
56	Tyrrell and Crow 1994	Outer Island	H	>175 years; few or no stumps; hemlock (60% by basal area)
56	Tyrrell and Crow 1994	Patterson	H-WP	>175 years; few or no stumps; hemlock (55% by basal area)-white pine (20%)
56	Tyrrell and Crow 1994	Plum	H	>175 years; few or no stumps; hemlock (76% by basal area)
56	Tyrrell and Crow 1994	Popple	H	>175 years; few or no stumps; hemlock (61% by basal area)-white pine (8%)
56	Tyrrell and Crow 1994	Pukall	H	>175 years; few or no stumps; hemlock (59% by basal area)
56	Tyrrell and Crow 1994	Salsich	H	>175 years; few or no stumps; hemlock (77% by basal area)
56	Tyrrell and Crow 1994	Scott	H-WP	>175 years; few or no stumps; hemlock (52% by basal area)-white pine (29%)
56	Tyrrell and Crow 1994	Sweeny	H	>175 years; few or no stumps; hemlock (69% by basal area)
56	Tyrrell and Crow 1994	Tucker	H	>175 years; few or no stumps; hemlock (71% by basal area)
56	Tyrrell and Crow 1994	Wabikon	H	>175 years; few or no stumps; hemlock (75% by basal area)
56	Tyrrell and Crow 1994	Woodland	H	>175 years; few or no stumps; hemlock (72% by basal area)
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1965	RS[5]	Old-age transitional; lumbering in late 1800's; sugar maple-beech-yellow birch-red spruce
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1979	RS[5]	Old-age transitional; lumbering in late 1800's; sugar maple-beech-yellow birch-red spruce
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1983	RS[5]	Old-age transitional; lumbering in late 1800's; sugar maple-beech-yellow birch-red spruce
58	Whitney 1984	Hearts Content--Hemlock-1929	H-WP	Virgin; hemlock (82% of tree density >24 cm)
58	Whitney 1984	Hearts Content--Hemlock-1978	H-WP	Virgin; hemlock (71% of tree density >24 cm)
58	Whitney 1984	Hearts Content--Hemlock-Beech-1929	H-WP	Virgin; hemlock (36% of tree density >24 cm)
58	Whitney 1984	Hearts Content--Hemlock-Beech-1978	H-WP	Virgin; hemlock (32% of tree density >24 cm)
59	Widoff 1985	Big Reed Pond Reserve--Mixed Forest	RS	No timber harvest; mixed red spruce (35% by basal area >10 cm)-hardwoods

[1] Grades into mixed mesophytic type.

[2] Percentage of hemlock in upper cove forest.

[3] Old growth defined as: at least 67% of exposed crown area ≥26 cm d.b.h, with crown percentage for trees >46.0 cm dbh more than that for trees 26.0-45.9 cm dbh.

[4] For trees ≥10 cm.

[5] Grades into montane spruce-fir type.

[6] Percent composition by basal area.

[7] Average 38% hemlock.

[8] Average 34% hemlock.

[9] 39% conifers (hemlocks, balsam fir, white spruce, northern white-cedar).

[10] Grades into northern pine type.

[11] Also northern white-cedar.

[12] Conifers were eastern hemlock, eastern white pine, balsam fir, northern white-cedar.

Table 59.—*Methods used to study old-growth conifer-northern hardwoods (condensed from the cited references).*

Map Key	Source/Date	Stand	Sampling Methods
1	Allard and Leonard 1952	Cabin Mountain	Interviews; work with logs and stumps
2	Baldwin 1951	Bradford	1 0.1-ha square plot
3	Bard 1967	Mianus River Preserve--Gorge	25 100-m^2 quadrats located 40m apart
3	Bard 1967	Mianus River Preserve--Ridge	25 100-m^2 quadrats located 40m apart
4	Bieri and Anliot 1965	Cathedral State Park	6 plots varying in size from 530 to 892 m^2
5	Boone 1983	Henstep Valley--Upper Section	8 10 m x 50 m plots
6	Busing 1989	Long Branch Cove--Upper Stand-1930's	Live trees and gaps in 50 m x 120 m plot
6	Busing 1989	Long Branch Cove--Upper Stand-1980's	Cain sampled trees in 0.42-ha plot in 1930 (unpublished)
7	Busing and White 1993	Roaring Fork	3 100 m x 100 m plots; canopy % in 400 5 m x 5 m subplots
8	Carbonneau 1986a	HM-1 (Gibbs Brook)	2-7 20 m x 20 m plots
8	Carbonneau 1986a	HM-2 (Williams)	2-7 20 m x 20 m plots
9	Cogbill 1985	Big Reed Pond Reserve--Mixed Forest	Data from Prentiss and Carlisle forest inventory in 1985
10	Conkling 1978	Corrina	Field evaluation, sampling using prism, one tree cored
11	Dahir and Lorimer 1996	Porcupine Mountains--Presque Isle River	1 70.7 m x 70.7 m plot measured in 1981, 1992; gaps
11	Dahir and Lorimer 1996	Porcupine Mountains--Speakers Creek	1 70.7 m x 70.7 m plot measured in 1981, 1992; gaps
12	DeYoung 1979	Great Smoky Mtns--White Pine-Red Oak	29 0.04-ha plots
12	DeYoung 1979	Great Smoky Mtns--White Pine-White Oak	14 0.04-ha plots
13	Donahue 1954	Bear Creek Ravine--No Pine	10 10 m x 10 m plots spaced evenly along two transects
13	Donahue 1954	Bear Creek Ravine--With Pine	10 10 m x 10 m plots spaced evenly along two transects
14	Dunn et al 1983	Flambeau River	40 0.04-ha plots in 1967, 1973
15	Dunwiddie 1993	Bash Bish--A-Grinder Brook	2 0.1-ha circular plots placed to include older trees
15	Dunwiddie 1993	Bash Bish--B-Bash Bish Falls	1 0.1-ha circular plots placed to include older trees
15	Dunwiddie 1993	Cold River--A-Plots 2, 3, 4	3 0.1-ha circular plots placed to include older trees; 11 cores
15	Dunwiddie 1993	Cold River--B-Black Brook	3 0.1-ha circular plots placed to include older trees; 6 cores
15	Dunwiddie 1993	Cold River--D	2 0.1-ha circular plots placed to include older trees; 6 cores
15	Dunwiddie 1993	Cold River--E-Manning Brook-Plot 1	1 0.1-ha circular plot placed to include older trees; 2 cores
15	Dunwiddie 1993	Dunbar Brook--Plot 2	1 0.1-ha circular plot placed to include older trees; 2 cores
15	Dunwiddie 1993	Fife Brook--Plots 3, 4	2 0.1-ha circular plots placed to include older trees; 1 core
15	Dunwiddie 1993	Mt. Everett--Glen Brook	1 0.1-ha circular plot placed to include older trees
15	Dunwiddie 1993	Mt. Greylock--Deer Hill	1 0.1-ha circular plot placed to include older trees; 3 cores
15	Dunwiddie 1993	Mt. Greylock--Money Brook-Plot 3	1 0.1-ha circular plot placed to include older trees; 3 cores
15	Dunwiddie 1993	Parsonage Brook	1 0.1-ha circular plot placed to include older trees
16	Elliott 1953	Missaukee	Original land survey notes
17	Fassett 1944	Brule River Basin	Original land survey notes of 1852-1856
18	Foster 1988	Harvard Tract	Data from 0.04-ha plots (~1910), reconstruction; stumps
19	Frelich and Lorimer 1991	Huron Mountains	6 0.5-ha plots
19	Frelich and Lorimer 1991	Porcupine Mountains	46 0.5-ha plots

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Map Key	Source/Date	Stand	Sampling Methods
19	Frelich and Lorimer 1991	Sylvania	18 0.5-ha plots
19	Frelich and Lorimer 1991	23 stands in Upper Michigan	0.5-ha plots, one per stand
20	Gates and Nichols 1930	Pellston	Aged 175 stumps > 20 cm diameter and 185 live trees
21	Halpin 1990	Ramsey's Draft--Quad 1	0.1-ha plot
21	Halpin 1990	Ramsey's Draft--Quad 2	0.1-ha plot
21	Halpin 1990	Ramsey's Draft--Quad 3	0.1-ha plot
21	Halpin 1990	Ramsey's Draft--Quads 1-3	Combined data from 3 previous plots, plus one oak plot
22	Hett and Loucks 1976	Gardner Dam	Grid of several 15.2 m x 15.2 m plots
22	Hett and Loucks 1976	Northwest Lake	Grid of several 15.2 m x 15.2 m plots
22	Hett and Loucks 1976	Pot Lake	Grid of several 15.2 m x 15.2 m plots
22	Hett and Loucks 1976	West Branch	Grid of several 15.2 m x 15.2 m plots
23	Hough 1936	East Tionesta	587 0.04-ha plots
24	Hough and Forbes 1943	Cook Forest	Cites earlier studies
24	Hough and Forbes 1943	East Tionesta Creek Valley	Detailed tree age study on 10 0.4-ha plots
24	Hough and Forbes 1943	Stand Near Hearts Content	Intensive study of stump ages
25	Leak 1985a	Bartlett Ridge	18 prism plots located systematically 60-100 m apart
25	Leak 1985a	Bartlett 19	14 prism plots located systematically 60-100 m apart
25	Leak 1985a	Bartlett 26	21 prism plots located systematically 60-100 m apart
26	Leak 1987a	Bartlett Ridge	18 prism plots located systematically 60-100 m apart
26	Leak 1987a	Bartlett 19	14 prism plots located systematically 60-100 m apart
27	Leak 1987b	Bartlett--bedrock	Relocated 5 1012-m^2 1931-1932 plots on 100 m x 200 m grid
27	Leak 1987b	Bartlett--dry compact till	Relocated 5 1012-m^2 1931-1932 plots on 100 m x 200 m grid
27	Leak 1987b	Bartlett--outwash	Relocated 2 1012-m^2 1931-1932 plots on 100 m x 200 m grid
27	Leak 1987b	Bartlett--wet compact till	Relocated 2 1012-m^2 1931-1932 plots on 100 m x 200 m grid
28	Leak and Graber 1974	Mt. Whiteface (The Bowl)	Prism plots and largest d.b.h. at 50-m elevation intervals
29	Leverett 1988	Dunbar Brook	Walk-through
30	Lutz 1930c	Hearts Content--Hemlock	37 0.4-ha plots along strips 20 m wide
30	Lutz 1930c	Hearts Content--Hemlock-Beech	126 0.4-ha plots along strips 20 m wide
31	Maine Critical Areas Program 1983b	Adams Pond Hemlock	Field evaluation with notes, 0.1-ha plots, cores
31	Maine Critical Areas Program 1983b	Bald Mountain	Field evaluation with notes, plots, prisms, and/or cores
31	Maine Critical Areas Program 1983b	Chesuncook Lake	Field evaluation with notes, plots and/or prisms, 5 cores
31	Maine Critical Areas Program 1983b	Farm Cove Mountain Hemlock	Field evaluation with notes, plots, prisms, and/or cores
31	Maine Critical Areas Program 1983b	Hollis White Pine - Hemlock	Field evaluation with notes, plots, prisms, and/or cores
31	Maine Critical Areas Program 1983b	Huston Brook	Field evaluation with notes, plots, prisms, and/or cores
31	Maine Critical Areas Program 1983b	Mattawamkeag River Hemlock	Field evaluation with notes, plots, prisms, and/or cores
31	Maine Critical Areas Program 1983b	Moosehorn Stream	Field evaluation with notes, plots and/or prisms, 7 cores
31	Maine Critical Areas Program 1983b	Mt. Christopher Hemlock	Field evaluation with notes, plots, prisms, and/or cores

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Map Key	Source/Date	Stand	Sampling Methods
31	Maine Critical Areas Program 1983b	Newcastle	Field evaluation with notes, plots, prisms, and/or cores
31	Maine Critical Areas Program 1983b	No. 3 Pond Hemlock	Field evaluation with notes, plots, 3 prism plots, 4 cores
31	Maine Critical Areas Program 1983b	Ocean Park White Pine - Hemlock	Field evaluation with notes, plots and/or prisms, 5 cores
31	Maine Critical Areas Program 1983b	Pine Stream Flowage	Field evaluation with notes, plots and/or prisms, 9 cores
31	Maine Critical Areas Program 1983b	Pleasant Lake Hemlock	Field evaluation with notes, plots, prisms, and/or cores
31	Maine Critical Areas Program 1983b	Prentiss Woods White Pine- Hemlock	Field evaluation with notes, plots, 4 prism plots, 6 cores
31	Maine Critical Areas Program 1983b	Sabao Lake Hemlock	Field evaluation with notes, plots, prisms, and/or cores
31	Maine Critical Areas Program 1983b	Thomas Point Hemlock	Field evaluation with notes, plots, prisms, and/or cores
31	Maine Critical Areas Program 1983b	Waldoboro Hemlock	Field evaluation with notes, plots and/or prisms, 7 cores
31	Maine Critical Areas Program 1983b	Wassataquoik Stream White Pine	Field evaluation with notes, plots and/or prisms, 3 cores
32	Meyer and Stevenson 1943	Dunham--Stands 13-16	Stands "calipered"
32	Meyer and Stevenson 1943	Larson--Stands 11-12	Stands "calipered"
32	Meyer and Stevenson 1943	McClure--Stand 1	Stands "calipered"
32	Meyer and Stevenson 1943	Ricketts--Stands 4-5	Stands "calipered"
32	Meyer and Stevenson 1943	Rightmeier--Stands 6-10	Stands "calipered"
32	Meyer and Stevenson 1943	Tionesta--Stands 17-26	Stands "calipered"
33	Milfred et al. 1967	Stand 10	5 circular 0.04-ha plots per stand
33	Milfred et al. 1967	Stand 27	5 circular 0.04-ha plots per stand
33	Milfred et al. 1967	Stand 35	5 circular 0.04-ha plots per stand
34	Mladenoff and Howell 1980	Gogebic Range	Government land survey data for 1860's
35	Morey 1936a	Cook Forest	Wood's 1930 tally in 14 strip plots of 0.20 ha (unpublished)
35	Morey 1936a	Hearts Content--Beech-Hemlock	25 0.20-ha plots
35	Morey 1936a	Hearts Content--Hemlock	7 0.20-ha plots
36	Morey 1936b	Hearts Content	Ages and diameters of 800 stumps, diameters of 600 trees
37	Nichols 1913	Colebrook Forest	Diameters and heights of trees, stumps; ring counts
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 1	20 points (point-quarter method) at 20-30 m along transects
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 2	20 points (point-quarter method) at 20-30 m along transects
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 3	20 points (point-quarter method) at 20-30 m along transects
38	Nowacki and Abrams 1994	Alan Seeger--Stream Terrace 1	20 points (point-quarter method) at 20-30 m along transects
38	Nowacki and Abrams 1994	Alan Seeger--Stream Terrace 2	20 points (point-quarter method) at 20-30 m along transects
39	Nowak 1993	Tionesta--RNAOG1	20 sample points (Bitterlich); 1.8 m x 40 m strip transects for snags and logs
39	Nowak 1993	Tionesta--RNAOG2	20 sample points (Bitterlich); 1.8 m x 40 m strip transects for snags and logs
39	Nowak 1993	Tionesta--RNAOG3	20 sample points (Bitterlich); 1.8 m x 40 m strip transects for snags and logs
40	Oosting and Billings 1939	Ravenel's Woods--Polycodium type	10 100-m^2 quadrats spaced in 2 rows
40	Oosting and Billings 1939	Ravenel's Woods--Rhododendron type	20 100-m^2 quadrats spaced at 20-m intervals
41	Oosting and Bourdeau 1955	Joyce Kilmer--Forest-Herb Type	10 100-m^2 plots chosen randomly within 3 stands
41	Oosting and Bourdeau 1955	Joyce Kilmer--Forest-Rhododendron Type	10 100-m^2 plots chosen randomly within 3 stands

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(Table 59 continued)

Map Key	Source/Date	Stand	Sampling Methods
42	Pinette and Rowe 1987	East Pinnacles	6 10 BAF prism plots (variable radius) 40 m apart
42	Pinette and Rowe 1987	Scraggly Lake	6 10 BAF prism plots (variable radius) 40 m apart
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 3	7 15 m x 30 m plots
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 6	3 15 m x 30 m plots
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 8	4 15 m x 30 m plots
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 10	4 15 m x 30 m plots
44	Runkle 1982	Huyck Preserve	Point-centered quarter method, gap tally along transects
44	Runkle 1982	Joyce Kilmer Wilderness Area	Point-centered quarter method, gap tally along transects
44	Runkle 1982	Tionesta Scenic and Research Natural Areas	Point-centered quarter method, gap tally along transects
44	Runkle 1982	Woodbourne Forest and Wildlife Sanctuary	Point-centered quarter method, gap tally along transects
45	Runkle 1991	Huyck Preserve--1978	Mapped stems in 2.02 ha
45	Runkle 1991	Huyck Preserve--1986	Mapped stems in 2.02 ha
46	Schmalzer 1978	Doe Creek, Little Piney Creek, Obed River	9 circular 0.04-ha plots, stratified random
47	Scott 1984	South Manitou Island	12 250-m^2 circular plots [1]
48	Scott and Murphy 1986	South Manitou Island	12 250-m^2 circular plots
49	Stearns 1949	T35N, R14E, Sections 18,30	35 100-m^2 quadrats
50	Stearns 1950	Gillen Refuge	4 100-m^2 quadrats
51	Tritton and Siccama 1990	Catlin Wood	Used data set from G.Loery and J.Greenwood
51	Tritton and Siccama 1990	Eastwoods	Used data set from FORAST
51	Tritton and Siccama 1990	Heart's Content	Used data set from G.Whitney
52	Tyrrell 1988a	Moose Lake Hemlocks	20 10 m x 25 m plots arranged systematically on grid
53	Tyrrell 1988b	Patterson Hemlocks	20 10 m x 25 m plots arranged systematically on grid
54	Tyrrell 1988c	Plum Lake Hemlocks	20 10 m x 25 m plots arranged systematically on grid
55	Tyrrell 1989	Scott Lake - Shelp Lake	20 10 m x 25 m plots arranged systematically on grid
56	Tyrrell and Crow 1994	Argonne	12 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Escanaba	7 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Glimmerglass	6 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Helen	9 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	High	1 10 m x 50 m plot arranged in stratified random design
56	Tyrrell and Crow 1994	Holmboe	6 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Island	2 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Keego	4 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Kemp	13 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Laura	9 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Lois	11 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Memorial Grove	19 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Moose	7 10 m x 50 m plots arranged in stratified random design

(Table 59 continued on next page)

(Table 59 continued)

Map Key	Source/Date	Stand	Sampling Methods
56	Tyrrell and Crow 1994	One Stone	11 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Outer Island	15 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Patterson	16 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Plum	17 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Popple	18 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Pukall	19 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Salsich	9 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Scott	8 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Sweeny	14 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Tucker	17 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Wabikon	2 10 m x 50 m plots arranged in stratified random design
56	Tyrrell and Crow 1994	Woodland	2 10 m x 50 m plots arranged in stratified random design
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1965	3 m x 30.5 m plots at 60-m elevation intervals 550-1160m
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1979	3 m x 30.5 m plots at 60-m elevation intervals 550-1160m
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1983	3 m x 30.5 m plots at 60-m elevation intervals 550-1160m
58	Whitney 1984	Hearts Content--Hemlock-1929	37 0.04-ha plots along belt transects [2]
58	Whitney 1984	Hearts Content--Hemlock-1978	36 0.04-ha plots (1 destroyed)
58	Whitney 1984	Hearts Content--Hemlock-Beech-1929	126 0.04-ha plots along belt transects [2]
58	Whitney 1984	Hearts Content--Hemlock-Beech-1978	116 0.04-ha plots (11 destroyed)
59	Widoff 1985	Big Reed Pond Reserve--Mixed Forest	20 m x 20 m plots

[1] Only reporting what is not already reported from Scott and Murphy (1986).

[2] Lutz set up the plots in 1929, as described in Lutz (1930).

Table 60.—*Density of live trees ≥10, ≥50, and ≥70 cm for conifer-northern hardwood old-growth study sites. For other minimum sizes, the density is listed under "≥X cm" and "≥Y cm", with the minimum size for tallying trees given as "Min Diam X" and "Min Diam Y", respectively.*

			Live Tree Density						
Map Key	Source/Date	Stand	≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X cm (#/ha)	Min Diam X (cm)	≥Y cm (#/ha)	Min Diam Y (cm)
1	Allard and Leonard 1952	Cabin Mountain							
2	Baldwin 1951	Bradford				889	5		
3	Bard 1967	Mianus River Preserve--Gorge				1384	2.54	136	30
3	Bard 1967	Mianus River Preserve--Ridge				1452	2.54	76	30
4	Bieri and Anliot 1965	Cathedral State Park		74 [1]		359	2.54	225 [1]	12.7
5	Boone 1983	Henstep Valley--Upper Section				1255	15		
6	Busing 1989	Long Branch Cove--Upper Stand-1930's							
6	Busing 1989	Long Branch Cove--Upper Stand-1980's							
7	Busing and White 1993	Roaring Fork							
8	Carbonneau 1986a	HM-1 (Gibbs Brook)	638	}55 [2]	}0 [2]				
8	Carbonneau 1986a	HM-2 (Williams)	438	}	}				
9	Cogbill 1985	Big Reed Pond Reserve--Mixed Forest							
10	Conkling 1978	Corrina							
11	Dahir and Lorimer 1996	Porcupine Mountains--Presque Isle River							
11	Dahir and Lorimer 1996	Porcupine Mountains--Speakers Creek							
12	DeYoung 1979	Great Smoky Mtns--White Pine-Red Oak	990						
12	DeYoung 1979	Great Smoky Mtns--White Pine-White Oak	963						
13	Donahue 1954	Bear Creek Ravine--No Pine				1450	2.5		
13	Donahue 1954	Bear Creek Ravine--With Pine				1130	2.5		
14	Dunn et al 1983	Flambeau River	414						
15	Dunwiddie 1993	Bash Bish--A-Grinder Brook	405			185	35		
15	Dunwiddie 1993	Bash Bish--B-Bash Bish Falls	430			200	35		
15	Dunwiddie 1993	Cold River--A-Plots 2, 3, 4	470			130	35		
15	Dunwiddie 1993	Cold River--B-Black Brook	443			110	35		
15	Dunwiddie 1993	Cold River--D	465			130	35		
15	Dunwiddie 1993	Cold River--E-Manning Brook-Plot 1	370			100	35		
15	Dunwiddie 1993	Dunbar Brook--Plot 2	320			130	35		
15	Dunwiddie 1993	Fife Brook--Plots 3, 4	400			100	35		
15	Dunwiddie 1993	Mt. Everett--Glen Brook	310			130	35		
15	Dunwiddie 1993	Mt. Greylock--Deer Hill	670			90	35		
15	Dunwiddie 1993	Mt. Greylock--Money Brook-Plot 3	370			80	35		
15	Dunwiddie 1993	Parsonage Brook	600			200	35		
16	Elliott 1953	Missaukee							
17	Fassett 1944	Brule River Basin							
18	Foster 1988	Harvard Tract				400	unspecified		
19	Frelich and Lorimer 1991	Huron Mountains							
19	Frelich and Lorimer 1991	Porcupine Mountains							

(Table 60 continued on next page)

(Table 60 continued)

			Live Tree Density						
Map Key	Source/Date	Stand	≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X cm (#/ha)	Min Diam X (cm)	≥Y cm (#/ha)	Min Diam Y (cm)
19	Frelich and Lorimer 1991	Sylvania							
19	Frelich and Lorimer 1991	23 stands in Upper Michigan	354-572						
20	Gates and Nichols 1930	Pellston							
21	Halpin 1990	Ramsey's Draft--Quad 1	273						
21	Halpin 1990	Ramsey's Draft--Quad 2	346						
21	Halpin 1990	Ramsey's Draft--Quad 3	427						
21	Halpin 1990	Ramsey's Draft--Quads 1-3	400	70		6	100		
22	Hett and Loucks 1976	Gardner Dam				692	8.9		
22	Hett and Loucks 1976	Northwest Lake				519	8.9		
22	Hett and Loucks 1976	Pot Lake				618	8.9		
22	Hett and Loucks 1976	West Branch				519	8.9		
23	Hough 1936	East Tionesta							
24	Hough and Forbes 1943	Cook Forest							
24	Hough and Forbes 1943	East Tionesta Creek Valley							
24	Hough and Forbes 1943	Stand Near Hearts Content							
25	Leak 1985a	Bartlett Ridge							
25	Leak 1985a	Bartlett 19							
25	Leak 1985a	Bartlett 26							
26	Leak 1987a	Bartlett Ridge							
26	Leak 1987a	Bartlett 19							
27	Leak 1987b	Bartlett--bedrock							
27	Leak 1987b	Bartlett--dry compact till							
27	Leak 1987b	Bartlett--outwash							
27	Leak 1987b	Bartlett--wet compact till							
28	Leak and Graber 1974	Mt. Whiteface (The Bowl)							
29	Leverett 1988	Dunbar Brook							
30	Lutz 1930c	Hearts Content--Hemlock							
30	Lutz 1930c	Hearts Content--Hemlock-Beech							
31	Maine Critical Areas Program 1983b	Adams Pond Hemlock							
31	Maine Critical Areas Program 1983b	Bald Mountain							
31	Maine Critical Areas Program 1983b	Chesuncook Lake							
31	Maine Critical Areas Program 1983b	Farm Cove Mountain Hemlock							
31	Maine Critical Areas Program 1983b	Hollis White Pine - Hemlock							
31	Maine Critical Areas Program 1983b	Huston Brook							
31	Maine Critical Areas Program 1983b	Mattawamkeag River Hemlock							
31	Maine Critical Areas Program 1983b	Moosehorn Stream							
31	Maine Critical Areas Program 1983b	Mt. Christopher Hemlock							

(Table 60 continued on next page)

(Table 60 continued)

			Live Tree Density						
Map Key	Source/Date	Stand	≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X cm (#/ha)	Min Diam X (cm)	≥Y cm (#/ha)	Min Diam Y (cm)
31	Maine Critical Areas Program 1983b	Newcastle							
31	Maine Critical Areas Program 1983b	No. 3 Pond Hemlock							
31	Maine Critical Areas Program 1983b	Ocean Park White Pine - Hemlock							
31	Maine Critical Areas Program 1983b	Pine Stream Flowage							
31	Maine Critical Areas Program 1983b	Pleasant Lake Hemlock							
31	Maine Critical Areas Program 1983b	Prentiss Woods White Pine- Hemlock							
31	Maine Critical Areas Program 1983b	Sabao Lake Hemlock							
31	Maine Critical Areas Program 1983b	Thomas Point Hemlock							
31	Maine Critical Areas Program 1983b	Waldoboro Hemlock							
31	Maine Critical Areas Program 1983b	Wassataquoik Stream White Pine							
32	Meyer and Stevenson 1943	Dunham--Stands 13-16				163	17.8		
32	Meyer and Stevenson 1943	Larson--Stands 11-12				221	17.8		
32	Meyer and Stevenson 1943	McClure--Stand 1				213	17.8		
32	Meyer and Stevenson 1943	Ricketts--Stands 4-5				231	17.8		
32	Meyer and Stevenson 1943	Rightmeier--Stands 6-10				234	17.8		
32	Meyer and Stevenson 1943	Tionesta--Stands 17-26				199	17.8		
33	Milfred et al. 1967	Stand 10		54[3]	15	934	8.9	1091	2.5
33	Milfred et al. 1967	Stand 27		69[3]	30	573	8.9	1264	2.5
33	Milfred et al. 1967	Stand 35		44[3]	10	588	8.9	845	2.5
34	Mladenoff and Howell 1980	Gogebic Range				546	unspecified		
35	Morey 1936a	Cook Forest	323			247	25		
35	Morey 1936a	Hearts Content--Beech-Hemlock	301			153	25		
35	Morey 1936a	Hearts Content--Hemlock	333			175	25		
36	Morey 1936b	Hearts Content							
37	Nichols 1913	Colebrook Forest							
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 1	570						
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 2	600						
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 3	267						
38	Nowacki and Abrams 1994	Alan Seeger--Stream Terrace 1	561						
38	Nowacki and Abrams 1994	Alan Seeger--Stream Terrace 2	758						
39	Nowak 1993	Tionesta--RNAOG1	388	78	24	}842[4]	2.54	}148[4]	28
39	Nowak 1993	Tionesta--RNAOG2	314	60	22	}		}	
39	Nowak 1993	Tionesta--RNAOG3	210	49	19	}		}	
40	Oosting and Billings 1939	Ravenel's Woods--Polycodium type				800[5]	2.5		
40	Oosting and Billings 1939	Ravenel's Woods--Rhododendron type				1800[5]	2.5		
41	Oosting and Bourdeau 1955	Joyce Kilmer--Forest-Herb Type		7		730	2.5	153	25
41	Oosting and Bourdeau 1955	Joyce Kilmer--Forest-Rhododendron Type		10		1827	2.5	177	25

(Table 60 continued on next page)

(Table 60 continued)

Map Key	Source/Date	Stand	Live Tree Density ≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X cm (#/ha)	Min Diam X (cm)	≥Y cm (#/ha)	Min Diam Y (cm)
42	Pinette and Rowe 1987	East Pinnacles							
42	Pinette and Rowe 1987	Scraggly Lake							
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 3							
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 6							
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 8							
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 10							
44	Runkle 1982	Huyck Preserve							
44	Runkle 1982	Joyce Kilmer Wilderness Area							
44	Runkle 1982	Tionesta Scenic and Research Natural Areas							
44	Runkle 1982	Woodbourne Forest and Wildlife Sanctuary							
45	Runkle 1991	Huyck Preserve--1978							
45	Runkle 1991	Huyck Preserve--1986				785	11		
46	Schmalzer 1978	Doe Creek, Little Piney Creek, Obed River				460	12.5		
47	Scott 1984	South Manitou Island							
48	Scott and Murphy 1986	South Manitou Island	345			884	2.54		
49	Stearns 1949	T35N, R14E, Sections 18,30				301	25.4	349	17.8
50	Stearns 1950	Gillen Refuge				1998	2.54	299	30.5
51	Tritton and Siccama 1990	Catlin Wood	447						
51	Tritton and Siccama 1990	Eastwoods	609						
51	Tritton and Siccama 1990	Heart's Content	366						
52	Tyrrell 1988a	Moose Lake Hemlocks	364	72	6				
53	Tyrrell 1988b	Patterson Hemlocks	570	74	28				
54	Tyrrell 1988c	Plum Lake Hemlocks	496	44	2				
55	Tyrrell 1989	Scott Lake - Shelp Lake	450	62	20				
56	Tyrrell and Crow 1994	Argonne	1031	32	2				
56	Tyrrell and Crow 1994	Escanaba	597	37	0				
56	Tyrrell and Crow 1994	Glimmerglass	507	47	3				
56	Tyrrell and Crow 1994	Helen	438	53	18				
56	Tyrrell and Crow 1994	High	1080	20	0				
56	Tyrrell and Crow 1994	Holmboe	840	17	0				
56	Tyrrell and Crow 1994	Island	400	80	10				
56	Tyrrell and Crow 1994	Keego	685	25	0				
56	Tyrrell and Crow 1994	Kemp	615	42	3				
56	Tyrrell and Crow 1994	Laura	491	40	2				
56	Tyrrell and Crow 1994	Lois	427	76	16				
56	Tyrrell and Crow 1994	Memorial Grove	305	82	12				
56	Tyrrell and Crow 1994	Moose	414	74	6				

(Table 60 continued on next page)

(Table 60 continued)

Map Key	Source/Date	Stand	Live Tree Density ≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X cm (#/ha)	Min Diam X (cm)	≥Y cm (#/ha)	Min Diam Y (cm)
56	Tyrrell and Crow 1994	One Stone	713	31	0				
56	Tyrrell and Crow 1994	Outer Island	415	64	15				
56	Tyrrell and Crow 1994	Patterson	562	42	11				
56	Tyrrell and Crow 1994	Plum	546	50	2				
56	Tyrrell and Crow 1994	Popple	1173	7	0				
56	Tyrrell and Crow 1994	Pukall	716	31	0				
56	Tyrrell and Crow 1994	Salsich	391	62	7				
56	Tyrrell and Crow 1994	Scott	470	68	25				
56	Tyrrell and Crow 1994	Sweeny	497	40	1				
56	Tyrrell and Crow 1994	Tucker	365	56	14				
56	Tyrrell and Crow 1994	Wabikon	490	10	0				
56	Tyrrell and Crow 1994	Woodland	410	70	0				
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1965				4289	2		
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1979				1889	2		
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1983				1916	2		
58	Whitney 1984	Hearts Content--Hemlock-1929				301 [6]	8.9		
58	Whitney 1984	Hearts Content--Hemlock-1978				358	8.9		
58	Whitney 1984	Hearts Content--Hemlock-Beech-1929				333 [6]	8.9		
58	Whitney 1984	Hearts Content--Hemlock-Beech-1978				413	8.9		
59	Widoff 1985	Big Reed Pond Reserve--Mixed Forest	648	29					

[1] Density for hemlock only.

[2] Density was interpreted from graph for HM-1 and HM-2 combined.

[3] Density is for trees >47.0 cm.

[4] Average for old-growth sites.

[5] Density is for dominant hemlocks only.

[6] See Morey (1936a).

Table 61.—*Basal area of live trees ≥10, ≥50, and ≥70 cm for conifer-northern hardwood old-growth study sites. For other minimum sizes, the basal area is listed under "≥X cm" and "≥Y cm", with the minimum size for tallying trees given as "Min Diam X" and "Min Diam Y", respectively.*

			Live Tree Basal Area (BA)						
Map Key	**Source/Date**	**Stand**	**≥10 cm (m^2/ha)**	**≥50 cm (m^2/ha)**	**≥70 cm (m^2/ha)**	**≥X cm (m^2/ha)**	**Min Diam X (cm)**	**≥Y cm (m^2/ha)**	**Min Diam Y (cm)**
1	Allard and Leonard 1952	Cabin Mountain							
2	Baldwin 1951	Bradford	147.6						
3	Bard 1967	Mianus River Preserve--Gorge				32.6	2.5		
3	Bard 1967	Mianus River Preserve--Ridge				23.5	2.5		
4	Bieri and Anliot 1965	Cathedral State Park				63.7	12.7		
5	Boone 1983	Henstep Valley--Upper Section							
6	Busing 1989	Long Branch Cove--Upper Stand-1930's				38.9	ht > 1.4 m		
6	Busing 1989	Long Branch Cove--Upper Stand-1980's				27.1	ht > 1.4 m		
7	Busing and White 1993	Roaring Fork							
8	Carbonneau 1986a	HM-1 (Gibbs Brook)	42.0						
8	Carbonneau 1986a	HM-2 (Williams)	37.6						
9	Cogbill 1985	Big Reed Pond Reserve--Mixed Forest	24.5						
10	Conkling 1978	Corrina							
11	Dahir and Lorimer 1996	Porcupine Mountains--Presque Isle River				51.3	4	34.0	46
11	Dahir and Lorimer 1996	Porcupine Mountains--Speakers Creek				52.9	4	34.3	46
12	DeYoung 1979	Great Smoky Mtns--White Pine-Red Oak	55.9						
12	DeYoung 1979	Great Smoky Mtns--White Pine-White Oak	64.3						
13	Donahue 1954	Bear Creek Ravine--No Pine							
13	Donahue 1954	Bear Creek Ravine--With Pine							
14	Dunn et al 1983	Flambeau River	48.5						
15	Dunwiddie 1993	Bash Bish--A-Grinder Brook	40.2			31.5	35		
15	Dunwiddie 1993	Bash Bish--B-Bash Bish Falls	44.7			29.4	35		
15	Dunwiddie 1993	Cold River--A-Plots 2, 3, 4	36.9			25.7	35		
15	Dunwiddie 1993	Cold River--B-Black Brook	35.2			25.8	35		
15	Dunwiddie 1993	Cold River--D	41.5			30.1	35		
15	Dunwiddie 1993	Cold River--E-Manning Brook-Plot 1	40.1			30.6	35		
15	Dunwiddie 1993	Dunbar Brook--Plot 2	44.7			37.6	35		
15	Dunwiddie 1993	Fife Brook--Plots 3, 4	43.6			33.3	35		
15	Dunwiddie 1993	Mt. Everett--Glen Brook	40.1			36.6	35		
15	Dunwiddie 1993	Mt. Greylock--Deer Hill	35.5			17.7	35		
15	Dunwiddie 1993	Mt. Greylock--Money Brook-Plot 3	23.9			16.7	35		
15	Dunwiddie 1993	Parsonage Brook	52.2			37.2	35		
16	Elliott 1953	Missaukee							
17	Fassett 1944	Brule River Basin							
18	Foster 1988	Harvard Tract				75	unspecified		
19	Frelich and Lorimer 1991	Huron Mountains							
19	Frelich and Lorimer 1991	Porcupine Mountains							

(Table 61 continued on next page)

(Table 61 continued)

Map Key	Source/Date	Stand	Live Tree Basal Area (BA) ≥10 cm (m^2/ha)	≥50 cm (m^2/ha)	≥70 cm (m^2/ha)	≥X cm (m^2/ha)	Min Diam X (cm)	≥Y cm (m^2/ha)	Min Diam Y (cm)
19	Frelich and Lorimer 1991	Sylvania							
19	Frelich and Lorimer 1991	23 stands in Upper Michigan	33.6-64.1						
20	Gates and Nichols 1930	Pellston							
21	Halpin 1990	Ramsey's Draft--Quad 1	41.5						
21	Halpin 1990	Ramsey's Draft--Quad 2	43.7						
21	Halpin 1990	Ramsey's Draft--Quad 3	33.5						
21	Halpin 1990	Ramsey's Draft--Quads 1-3	39.3						
22	Hett and Loucks 1976	Gardner Dam							
22	Hett and Loucks 1976	Northwest Lake							
22	Hett and Loucks 1976	Pot Lake							
22	Hett and Loucks 1976	West Branch							
23	Hough 1936	East Tionesta				32.3	8.9		
24	Hough and Forbes 1943	Cook Forest							
24	Hough and Forbes 1943	East Tionesta Creek Valley							
24	Hough and Forbes 1943	Stand Near Hearts Content							
25	Leak 1985a	Bartlett Ridge				42.9	5	39.5	15.2
25	Leak 1985a	Bartlett 19				53.5	5	49.6	15.2
25	Leak 1985a	Bartlett 26				47.1	5	41.8	15.2
26	Leak 1987a	Bartlett Ridge				42.9	5	0.76	66
26	Leak 1987a	Bartlett 19				53.4	5	0.83	66
27	Leak 1987b	Bartlett--bedrock				30.2-41.6 [1]	11.5		
27	Leak 1987b	Bartlett--dry compact till				31.0-41.5 [1]	11.5		
27	Leak 1987b	Bartlett--outwash				38.1	11.5		
27	Leak 1987b	Bartlett--wet compact till				45.1	11.5		
28	Leak and Graber 1974	Mt. Whiteface (The Bowl)							
29	Leverett 1988	Dunbar Brook							
30	Lutz 1930c	Hearts Content--Hemlock				39.0 [2]	25		
30	Lutz 1930c	Hearts Content--Hemlock-Beech				34.6 [3]	25		
31	Maine Critical Areas Program 1983b	Adams Pond Hemlock							
31	Maine Critical Areas Program 1983b	Bald Mountain							
31	Maine Critical Areas Program 1983b	Chesuncook Lake							
31	Maine Critical Areas Program 1983b	Farm Cove Mountain Hemlock							
31	Maine Critical Areas Program 1983b	Hollis White Pine - Hemlock							
31	Maine Critical Areas Program 1983b	Huston Brook							
31	Maine Critical Areas Program 1983b	Mattawamkeag River Hemlock							
31	Maine Critical Areas Program 1983b	Moosehorn Stream							
31	Maine Critical Areas Program 1983b	Mt. Christopher Hemlock							

(Table 61 continued on next page)

(Table 61 continued)

Map Key	Source/Date	Stand	Live Tree Basal Area (BA) ≥10 cm (m²/ha)	≥50 cm (m²/ha)	≥70 cm (m²/ha)	≥X cm (m²/ha)	Min Diam X (cm)	≥Y cm (m²/ha)	Min Diam Y (cm)
31	Maine Critical Areas Program 1983b	Newcastle							
31	Maine Critical Areas Program 1983b	No. 3 Pond Hemlock							
31	Maine Critical Areas Program 1983b	Ocean Park White Pine - Hemlock							
31	Maine Critical Areas Program 1983b	Pine Stream Flowage							
31	Maine Critical Areas Program 1983b	Pleasant Lake Hemlock							
31	Maine Critical Areas Program 1983b	Prentiss Woods White Pine- Hemlock							
31	Maine Critical Areas Program 1983b	Sabao Lake Hemlock							
31	Maine Critical Areas Program 1983b	Thomas Point Hemlock							
31	Maine Critical Areas Program 1983b	Waldoboro Hemlock							
31	Maine Critical Areas Program 1983b	Wassataquoik Stream White Pine							
32	Meyer and Stevenson 1943	Dunham--Stands 13-16							
32	Meyer and Stevenson 1943	Larson--Stands 11-12							
32	Meyer and Stevenson 1943	McClure--Stand 1							
32	Meyer and Stevenson 1943	Ricketts--Stands 4-5							
32	Meyer and Stevenson 1943	Rightmeier--Stands 6-10							
32	Meyer and Stevenson 1943	Tionesta--Stands 17-26							
33	Milfred et al. 1967	Stand 10							
33	Milfred et al. 1967	Stand 27							
33	Milfred et al. 1967	Stand 35							
34	Mladenoff and Howell 1980	Gogebic Range				55.8	unspecified		
35	Morey 1936a	Cook Forest	70.0						
35	Morey 1936a	Hearts Content--Beech-Hemlock	37.4						
35	Morey 1936a	Hearts Content--Hemlock	42.2						
36	Morey 1936b	Hearts Content							
37	Nichols 1913	Colebrook Forest							
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 1	55.3						
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 2	56.5						
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 3	36.1						
38	Nowacki and Abrams 1994	Alan Seeger--Stream Terrace 1	67.6						
38	Nowacki and Abrams 1994	Alan Seeger--Stream Terrace 2	59.1						
39	Nowak 1993	Tionesta--RNAOG1	44.0	27.0	12.0	} 36.7 [4]	2.54	} 16.5 [4]	58.4
39	Nowak 1993	Tionesta--RNAOG2	38.0	22.0	12.0	}		}	
39	Nowak 1993	Tionesta--RNAOG3	27.0	19.0	11.0	}		}	
40	Oosting and Billings 1939	Ravenel's Woods--Polycodium type				75.3 [5]	2.54		
40	Oosting and Billings 1939	Ravenel's Woods--Rhododendron type				98.5 [5]	2.54		
41	Oosting and Bourdeau 1955	Joyce Kilmer--Forest-Herb Type				45.2	2.54		
41	Oosting and Bourdeau 1955	Joyce Kilmer--Forest-Rhododendron Type				73.9	2.54		

(Table 61 continued on next page)

(Table 61 continued)

			Live Tree Basal Area (BA)						
Map Key	Source/Date	Stand	≥10 cm (m^2/ha)	≥50 cm (m^2/ha)	≥70 cm (m^2/ha)	≥X cm (m^2/ha)	Min Diam X (cm)	≥Y cm (m^2/ha)	Min Diam Y (cm)
42	Pinette and Rowe 1987	East Pinnacles	46.6						
42	Pinette and Rowe 1987	Scraggly Lake	26.4						
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 3	49.8						
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 6	61.7						
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 8	45.8						
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 10	29.3						
44	Runkle 1982	Huyck Preserve							
44	Runkle 1982	Joyce Kilmer Wilderness Area							
44	Runkle 1982	Tionesta Scenic and Research Natural Areas							
44	Runkle 1982	Woodbourne Forest and Wildlife Sanctuary							
45	Runkle 1991	Huyck Preserve--1978							
45	Runkle 1991	Huyck Preserve--1986							
46	Schmalzer 1978	Doe Creek, Little Piney Creek, Obed River				69.3	12.5		
47	Scott 1984	South Manitou Island							
48	Scott and Murphy 1986	South Manitou Island							
49	Stearns 1949	T35N, R14E, Sections 18,30							
50	Stearns 1950	Gillen Refuge				83.8	2.54		
51	Tritton and Siccama 1990	Catlin Wood	43.6						
51	Tritton and Siccama 1990	Eastwoods	39.2						
51	Tritton and Siccama 1990	Heart's Content	42.4						
52	Tyrrell 1988a	Moose Lake Hemlocks	40.7						
53	Tyrrell 1988b	Patterson Hemlocks	55.2						
54	Tyrrell 1988c	Plum Lake Hemlocks	49.6						
55	Tyrrell 1989	Scott Lake - Shelp Lake	51.9						
56	Tyrrell and Crow 1994	Argonne	63.7	7.8	0.8				
56	Tyrrell and Crow 1994	Escanaba	52.3	9.5	0				
56	Tyrrell and Crow 1994	Glimmerglass	40.2	13.4	1.3				
56	Tyrrell and Crow 1994	Helen	45.7	19.6	9.5				
56	Tyrrell and Crow 1994	High	63.6	4.8	0				
56	Tyrrell and Crow 1994	Holmboe	46.6	4.4	0				
56	Tyrrell and Crow 1994	Island	45.5	21.2	4.1				
56	Tyrrell and Crow 1994	Keego	52.9	6.4	0				
56	Tyrrell and Crow 1994	Kemp	52.8	11.0	1.4				
56	Tyrrell and Crow 1994	Laura	45.6	10.0	0.9				
56	Tyrrell and Crow 1994	Lois	46.4	24.4	8.7				
56	Tyrrell and Crow 1994	Memorial Grove	42.5	24.4	6.0				
56	Tyrrell and Crow 1994	Moose	42.8	20.8	3.3				

(Table 61 continued on next page)

(Table 61 continued)

			Live Tree Basal Area (BA)						
							Min Diam		Min Diam
Map Key	Source/Date	Stand	≥10 cm (m^2/ha)	≥50 cm (m^2/ha)	≥70 cm (m^2/ha)	≥X cm (m^2/ha)	X (cm)	≥Y cm (m^2/ha)	Y (cm)
56	Tyrrell and Crow 1994	One Stone	48.3	7.8	0				
56	Tyrrell and Crow 1994	Outer Island	43.6	21.6	8.1				
56	Tyrrell and Crow 1994	Patterson	44.6	13.8	5.3				
56	Tyrrell and Crow 1994	Plum	50.0	12.2	0.8				
56	Tyrrell and Crow 1994	Popple	50.7	1.7	0				
56	Tyrrell and Crow 1994	Pukall	49.4	7.3	0				
56	Tyrrell and Crow 1994	Salsich	45.9	17.3	2.8				
56	Tyrrell and Crow 1994	Scott	52.4	24.5	13.5				
56	Tyrrell and Crow 1994	Sweeny	41.9	10.0	0.6				
56	Tyrrell and Crow 1994	Tucker	39.6	18.6	7.0				
56	Tyrrell and Crow 1994	Wabikon	40.2	2.0	0				
56	Tyrrell and Crow 1994	Woodland	42.6	17.7	0				
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1965				26.5 [6]	2		
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1979				25.0 [7]	2		
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1983				21.3 [8]	2		
58	Whitney 1984	Hearts Content--Hemlock-1929							
58	Whitney 1984	Hearts Content--Hemlock-1978							
58	Whitney 1984	Hearts Content--Hemlock-Beech-1929							
58	Whitney 1984	Hearts Content--Hemlock-Beech-1978							
59	Widoff 1985	Big Reed Pond Reserve--Mixed Forest							

[1] Values different depending on elevation.

[2] Morey (1936a) reports 42.4 m^2/ha for basal area.

[3] Morey (1936a) reports 37.4 m^2/ha for basal area.

[4] Average for old-growth sites.

[5] Basal area is for dominant hemlocks only.

[6] Biomass of live trees was 135,700 kg/ha.

[7] Biomass of live trees was 145,300 kg/ha.

[8] Biomass of live trees was 120,000 kg/ha.

Table 62.—*Average and maximum tree age by species for conifer-northern hardwood old-growth study sites.*

Map Key	Source/Date	Stand	Average Tree Age (yr) Eastern Hemlock	E. White Pine	Red Spruce	Sugar Maple	Maximum Tree Age (yr) Eastern Hemlock	E. White Pine	Red Spruce	Sugar Maple	Yellow Birch	American Beech	Other
1	Allard and Leonard 1952	Cabin Mountain					350-375						
2	Baldwin 1951	Bradford					140	153					
3	Bard 1967	Mianus River Preserve--Gorge					}300 [1]						
3	Bard 1967	Mianus River Preserve--Ridge					}						
4	Bieri and Anliot 1965	Cathedral State Park											
5	Boone 1983	Henstep Valley--Upper Section											
6	Busing 1989	Long Branch Cove--Upper Stand-1930's											
6	Busing 1989	Long Branch Cove--Upper Stand-1980's											
7	Busing and White 1993	Roaring Fork											
8	Carbonneau 1986a	HM-1 (Gibbs Brook)											
8	Carbonneau 1986a	HM-2 (Williams)											
9	Cogbill 1985	Big Reed Pond Reserve--Mixed Forest			100				>161				
10	Conkling 1978	Corrina						145					
11	Dahir and Lorimer 1996	Porcupine Mountains--Presque Isle River											
11	Dahir and Lorimer 1996	Porcupine Mountains--Speakers Creek											
12	DeYoung 1979	Great Smoky Mtns--White Pine-Red Oak											
12	DeYoung 1979	Great Smoky Mtns--White Pine-White Oak											
13	Donahue 1954	Bear Creek Ravine--No Pine											
13	Donahue 1954	Bear Creek Ravine--With Pine											
14	Dunn et al 1983	Flambeau River											250-400
15	Dunwiddie 1993	Bash Bish--A-Grinder Brook											
15	Dunwiddie 1993	Bash Bish--B-Bash Bish Falls											
15	Dunwiddie 1993	Cold River--A-Plots 2, 3, 4					317		181				
15	Dunwiddie 1993	Cold River--B-Black Brook					219						
15	Dunwiddie 1993	Cold River--D					187		199	141			
15	Dunwiddie 1993	Cold River--E-Manning Brook-Plot 1					225						
15	Dunwiddie 1993	Dunbar Brook--Plot 2					303						
15	Dunwiddie 1993	Fife Brook--Plots 3, 4					189						
15	Dunwiddie 1993	Mt. Everett--Glen Brook											
15	Dunwiddie 1993	Mt. Greylock--Deer Hill					186		309				
15	Dunwiddie 1993	Mt. Greylock--Money Brook-Plot 3											
15	Dunwiddie 1993	Parsonage Brook											
16	Elliott 1953	Missaukee											
17	Fassett 1944	Brule River Basin											
18	Foster 1988	Harvard Tract											
19	Frelich and Lorimer 1991	Huron Mountains											
19	Frelich and Lorimer 1991	Porcupine Mountains											

(Table 62 continued on next page)

(Table 62 continued)

Map Key	Source/Date	Stand	Average Tree Age (yr) Eastern Hemlock	Average Tree Age (yr) E. White Pine	Average Tree Age (yr) Red Spruce	Average Tree Age (yr) Sugar Maple	Maximum Tree Age (yr) Eastern Hemlock	Maximum Tree Age (yr) E. White Pine	Maximum Tree Age (yr) Red Spruce	Maximum Tree Age (yr) Sugar Maple	Maximum Tree Age (yr) Yellow Birch	Maximum Tree Age (yr) American Beech	Other
19	Frelich and Lorimer 1991	Sylvania											
19	Frelich and Lorimer 1991	23 stands in Upper Michigan	178			145							573
20	Gates and Nichols 1930	Pellston					400+			351-400			
21	Halpin 1990	Ramsey's Draft--Quad 1											
21	Halpin 1990	Ramsey's Draft--Quad 2											
21	Halpin 1990	Ramsey's Draft--Quad 3											
21	Halpin 1990	Ramsey's Draft--Quads 1-3											
22	Hett and Loucks 1976	Gardner Dam											
22	Hett and Loucks 1976	Northwest Lake											
22	Hett and Loucks 1976	Pot Lake											
22	Hett and Loucks 1976	West Branch											
23	Hough 1936	East Tionesta					560						
24	Hough and Forbes 1943	Cook Forest						450					
24	Hough and Forbes 1943	East Tionesta Creek Valley		181			536	370		420	366	366	
24	Hough and Forbes 1943	Stand Near Hearts Content					260	300				290	
25	Leak 1985a	Bartlett Ridge											
25	Leak 1985a	Bartlett 19											
25	Leak 1985a	Bartlett 26											
26	Leak 1987a	Bartlett Ridge											
26	Leak 1987a	Bartlett 19											
27	Leak 1987b	Bartlett--bedrock											100-150 [2]
27	Leak 1987b	Bartlett--dry compact till											100-150 [2]
27	Leak 1987b	Bartlett--outwash											100-150 [2]
27	Leak 1987b	Bartlett--wet compact till											100-150 [2]
28	Leak and Graber 1974	Mt. Whiteface (The Bowl)											
29	Leverett 1988	Dunbar Brook											
30	Lutz 1930c	Hearts Content--Hemlock											
30	Lutz 1930c	Hearts Content--Hemlock-Beech						250					
31	Maine Critical Areas Program 1983b	Adams Pond Hemlock	177				260+		290+				
31	Maine Critical Areas Program 1983b	Bald Mountain						150 [3]					
31	Maine Critical Areas Program 1983b	Chesuncook Lake						356 [4]					
31	Maine Critical Areas Program 1983b	Farm Cove Mountain Hemlock					300+		120				
31	Maine Critical Areas Program 1983b	Hollis White Pine - Hemlock						160+					
31	Maine Critical Areas Program 1983b	Huston Brook						300					
31	Maine Critical Areas Program 1983b	Mattawamkeag River Hemlock					300+						
31	Maine Critical Areas Program 1983b	Moosehorn Stream						150	200				
31	Maine Critical Areas Program 1983b	Mt. Christopher Hemlock					170 [5]	170 [5]					

(Table 62 continued on next page)

(Table 62 continued)

Map Key	Source/Date	Stand	Average Tree Age (yr) Eastern Hemlock	Average Tree Age (yr) E. White Pine	Average Tree Age (yr) Red Spruce	Average Tree Age (yr) Sugar Maple	Maximum Tree Age (yr) Eastern Hemlock	Maximum Tree Age (yr) E. White Pine	Maximum Tree Age (yr) Red Spruce	Maximum Tree Age (yr) Sugar Maple	Maximum Tree Age (yr) Yellow Birch	Maximum Tree Age (yr) American Beech	Maximum Tree Age (yr) Other
31	Maine Critical Areas Program 1983b	Newcastle											
31	Maine Critical Areas Program 1983b	No. 3 Pond Hemlock	260-270 [6]				326						
31	Maine Critical Areas Program 1983b	Ocean Park White Pine - Hemlock					142	135					
31	Maine Critical Areas Program 1983b	Pine Stream Flowage						220					
31	Maine Critical Areas Program 1983b	Pleasant Lake Hemlock	200-250 [6]				250	200+	100				
31	Maine Critical Areas Program 1983b	Prentiss Woods White Pine- Hemlock					140+	150+					
31	Maine Critical Areas Program 1983b	Sabao Lake Hemlock					250+						
31	Maine Critical Areas Program 1983b	Thomas Point Hemlock					150						
31	Maine Critical Areas Program 1983b	Waldoboro Hemlock					240				150		
31	Maine Critical Areas Program 1983b	Wassataquoik Stream White Pine						150+					
32	Meyer and Stevenson 1943	Dunham--Stands 13-16											
32	Meyer and Stevenson 1943	Larson--Stands 11-12											
32	Meyer and Stevenson 1943	McClure--Stand 1											
32	Meyer and Stevenson 1943	Ricketts--Stands 4-5											
32	Meyer and Stevenson 1943	Rightmeier--Stands 6-10											
32	Meyer and Stevenson 1943	Tionesta--Stands 17-26											
33	Milfred et al. 1967	Stand 10											
33	Milfred et al. 1967	Stand 27					530						
33	Milfred et al. 1967	Stand 35											
34	Mladenoff and Howell 1980	Gogebic Range											
35	Morey 1936a	Cook Forest		232				400					
35	Morey 1936a	Hearts Content--Beech-Hemlock						}292 [7]					
35	Morey 1936a	Hearts Content--Hemlock						}					
36	Morey 1936b	Hearts Content					492	295			247	329	
37	Nichols 1913	Colebrook Forest	275 [8]										350 [8]
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 1											
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 2											
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 3											
38	Nowacki and Abrams 1994	Alan Seeger--Stream Terrace 1											
38	Nowacki and Abrams 1994	Alan Seeger--Stream Terrace 2											
39	Nowak 1993	Tionesta--RNAOG1											
39	Nowak 1993	Tionesta--RNAOG2											
39	Nowak 1993	Tionesta--RNAOG3											
40	Oosting and Billings 1939	Ravenel's Woods--Polycodium type											
40	Oosting and Billings 1939	Ravenel's Woods--Rhododendron type											
41	Oosting and Bourdeau 1955	Joyce Kilmer--Forest-Herb Type											
41	Oosting and Bourdeau 1955	Joyce Kilmer--Forest-Rhododendron Type											

(Table 62 continued on next page)

(Table 62 continued)

			Average Tree Age (yr)				Maximum Tree Age (yr)						
Map Key	Source/Date	Stand	Eastern Hemlock	E. White Pine	Red Spruce	Sugar Maple	Eastern Hemlock	E. White Pine	Red Spruce	Sugar Maple	Yellow Birch	American Beech	Other
42	Pinette and Rowe 1987	East Pinnacles	252+		97								198
42	Pinette and Rowe 1987	Scraggly Lake	175+		129	114							243
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 3											
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 6											
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 8											
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 10											
44	Runkle 1982	Huyck Preserve											
44	Runkle 1982	Joyce Kilmer Wilderness Area											
44	Runkle 1982	Tionesta Scenic and Research Natural Areas											
44	Runkle 1982	Woodbourne Forest and Wildlife Sanctuary											
45	Runkle 1991	Huyck Preserve--1978											
45	Runkle 1991	Huyck Preserve--1986											
46	Schmalzer 1978	Doe Creek, Little Piney Creek, Obed River											
47	Scott 1984	South Manitou Island											
48	Scott and Murphy 1986	South Manitou Island											
49	Stearns 1949	T35N, R14E, Sections 18,30											
50	Stearns 1950	Gillen Refuge						380					
51	Tritton and Siccama 1990	Catlin Wood											
51	Tritton and Siccama 1990	Eastwoods											
51	Tritton and Siccama 1990	Heart's Content											
52	Tyrrell 1988a	Moose Lake Hemlocks											
53	Tyrrell 1988b	Patterson Hemlocks											
54	Tyrrell 1988c	Plum Lake Hemlocks											
55	Tyrrell 1989	Scott Lake - Shelp Lake											
56	Tyrrell and Crow 1994	Argonne	193				235						
56	Tyrrell and Crow 1994	Escanaba	220				252						
56	Tyrrell and Crow 1994	Glimmerglass	245				350						
56	Tyrrell and Crow 1994	Helen	243				358						
56	Tyrrell and Crow 1994	High	186				238						
56	Tyrrell and Crow 1994	Holmboe	152				193						
56	Tyrrell and Crow 1994	Island	236				311						
56	Tyrrell and Crow 1994	Keego	185				235						
56	Tyrrell and Crow 1994	Kemp	200				261						
56	Tyrrell and Crow 1994	Laura	225				263						
56	Tyrrell and Crow 1994	Lois	217				319						
56	Tyrrell and Crow 1994	Memorial Grove	240				302						
56	Tyrrell and Crow 1994	Moose	203				275						

(Table 62 continued on next page)

(Table 62 continued)

Map Key	Source/Date	Stand	Average Tree Age (yr)				Maximum Tree Age (yr)						
			Eastern Hemlock	E. White Pine	Red Spruce	Sugar Maple	Eastern Hemlock	E. White Pine	Red Spruce	Sugar Maple	Yellow Birch	American Beech	Other
56	Tyrrell and Crow 1994	One Stone	196				221						
56	Tyrrell and Crow 1994	Outer Island	264				374						
56	Tyrrell and Crow 1994	Patterson	185				218						
56	Tyrrell and Crow 1994	Plum	184				252						
56	Tyrrell and Crow 1994	Popple	151				177						
56	Tyrrell and Crow 1994	Pukall	190				223						
56	Tyrrell and Crow 1994	Salsich	223				257						
56	Tyrrell and Crow 1994	Scott	205				240						
56	Tyrrell and Crow 1994	Sweeny	207				264						
56	Tyrrell and Crow 1994	Tucker	220				340						
56	Tyrrell and Crow 1994	Wabikon	166				241						
56	Tyrrell and Crow 1994	Woodland	211				266						
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1965											
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1979											
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1983											
58	Whitney 1984	Hearts Content--Hemlock-1929											
58	Whitney 1984	Hearts Content--Hemlock-1978											
58	Whitney 1984	Hearts Content--Hemlock-Beech-1929											
58	Whitney 1984	Hearts Content--Hemlock-Beech-1978											
59	Widoff 1985	Big Reed Pond Reserve--Mixed Forest											

[1] Not specified whether old tree was in gorge or ridge area.

[2] Estimated age in 1931-1932.

[3] Estimate.

[4] Estimate because of hollow center.

[5] Age of large trees.

[6] Average age of maximum age class.

[7] Not specified whether old tree is in hemlock or beech-hemlock area.

[8] Species not specified for average age (275 yr) or maximum age (350 yr) of trees.

Table 63.—*Maximum tree diameter by species, and percentage of the tree canopy in gaps for conifer-northern hardwood old-growth study sites.*

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm) Eastern Hemlock	E. White Pine	Red Spruce	Sugar Maple	Yellow Birch	N. White-Cedar	N. Red Oak	White Oak	Red Maple	White Ash	Am. Beech	Other	Canopy Gaps (%)
1	Allard and Leonard 1952	Cabin Mountain	175												
2	Baldwin 1951	Bradford		125											
3	Bard 1967	Mianus River Preserve--Gorge	}98[1]						}67[1]	}68[1]			}55[1]		
3	Bard 1967	Mianus River Preserve--Ridge	}						}	}			}		
4	Bieri and Anliot 1965	Cathedral State Park	198												
5	Boone 1983	Henstep Valley--Upper Section													
6	Busing 1989	Long Branch Cove--Upper Stand-1930's													
6	Busing 1989	Long Branch Cove--Upper Stand-1980's													11
7	Busing and White 1993	Roaring Fork													13
8	Carbonneau 1986a	HM-1 (Gibbs Brook)	}75[2]		}55[2]						}65[2]				
8	Carbonneau 1986a	HM-2 (Williams)	}		}						}				
9	Cogbill 1985	Big Reed Pond Reserve--Mixed Forest													
10	Conkling 1978	Corrina		86											
11	Dahir and Lorimer 1996	Porcupine Mountains--Presque Isle River													
11	Dahir and Lorimer 1996	Porcupine Mountains--Speakers Creek													
12	DeYoung 1979	Great Smoky Mtns--White Pine-Red Oak													
12	DeYoung 1979	Great Smoky Mtns--White Pine-White Oak													
13	Donahue 1954	Bear Creek Ravine--No Pine		100											
13	Donahue 1954	Bear Creek Ravine--With Pine		100											
14	Dunn et al 1983	Flambeau River													
15	Dunwiddie 1993	Bash Bish--A-Grinder Brook													
15	Dunwiddie 1993	Bash Bish--B-Bash Bish Falls													
15	Dunwiddie 1993	Cold River--A-Plots 2, 3, 4	80		49		60								
15	Dunwiddie 1993	Cold River--B-Black Brook	77										60		
15	Dunwiddie 1993	Cold River--D	76		57	70									
15	Dunwiddie 1993	Cold River--E-Manning Brook-Plot 1	76												
15	Dunwiddie 1993	Dunbar Brook--Plot 2	80												
15	Dunwiddie 1993	Fife Brook--Plots 3, 4	76												
15	Dunwiddie 1993	Mt. Everett--Glen Brook													
15	Dunwiddie 1993	Mt. Greylock--Deer Hill	73		46										
15	Dunwiddie 1993	Mt. Greylock--Money Brook-Plot 3													
15	Dunwiddie 1993	Parsonage Brook													
16	Elliott 1953	Missaukee		132											
17	Fassett 1944	Brule River Basin		91[3]										[3,4]	
18	Foster 1988	Harvard Tract													
19	Frelich and Lorimer 1991	Huron Mountains													2-13
19	Frelich and Lorimer 1991	Porcupine Mountains													3-10

(Table 63 continued on next page)

(Table 63 continued)

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm) Eastern Hemlock	E. White Pine	Red Spruce	Sugar Maple	Yellow Birch	N. White-Cedar	N. Red Oak	White Oak	Red Maple	White Ash	Am. Beech	Other	Canopy Gaps (%)
19	Frelich and Lorimer 1991	Sylvania													2-9
19	Frelich and Lorimer 1991	23 stands in Upper Michigan													
20	Gates and Nichols 1930	Pellston	90-100			90-100									
21	Halpin 1990	Ramsey's Draft--Quad 1													
21	Halpin 1990	Ramsey's Draft--Quad 2													
21	Halpin 1990	Ramsey's Draft--Quad 3													
21	Halpin 1990	Ramsey's Draft--Quads 1-3	130						100						
22	Hett and Loucks 1976	Gardner Dam		78											
22	Hett and Loucks 1976	Northwest Lake	78												
22	Hett and Loucks 1976	Pot Lake	78												
22	Hett and Loucks 1976	West Branch	60												
23	Hough 1936	East Tionesta													
24	Hough and Forbes 1943	Cook Forest													
24	Hough and Forbes 1943	East Tionesta Creek Valley													
24	Hough and Forbes 1943	Stand Near Hearts Content													
25	Leak 1985a	Bartlett Ridge													
25	Leak 1985a	Bartlett 19													
25	Leak 1985a	Bartlett 26													
26	Leak 1987a	Bartlett Ridge	81		56				51		51		61		
26	Leak 1987a	Bartlett 19	66	71	56		36				61		51		
27	Leak 1987b	Bartlett--bedrock												[5]	
27	Leak 1987b	Bartlett--dry compact till												[6]	
27	Leak 1987b	Bartlett--outwash												[7]	
27	Leak 1987b	Bartlett--wet compact till												[8]	
28	Leak and Graber 1974	Mt. Whiteface (The Bowl)			71/65 [9]	63/- [9]	72/32 [9]								
29	Leverett 1988	Dunbar Brook	126			97						116			
30	Lutz 1930c	Hearts Content--Hemlock	114												
30	Lutz 1930c	Hearts Content--Hemlock-Beech		102											
31	Maine Critical Areas Program 1983b	Adams Pond Hemlock													
31	Maine Critical Areas Program 1983b	Bald Mountain		94											
31	Maine Critical Areas Program 1983b	Chesuncook Lake		86											
31	Maine Critical Areas Program 1983b	Farm Cove Mountain Hemlock			46								36		
31	Maine Critical Areas Program 1983b	Hollis White Pine - Hemlock	54	94											
31	Maine Critical Areas Program 1983b	Huston Brook						64							
31	Maine Critical Areas Program 1983b	Mattawamkeag River Hemlock													
31	Maine Critical Areas Program 1983b	Moosehorn Stream		79	56										
31	Maine Critical Areas Program 1983b	Mt. Christopher Hemlock	51	66											

(Table 63 continued on next page)

(Table 63 continued)

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm)												Canopy Gaps (%)
			Eastern Hemlock	E. White Pine	Red Spruce	Sugar Maple	Yellow Birch	N. White-Cedar	N. Red Oak	White Oak	Red Maple	White Ash	Am. Beech	Other	
31	Maine Critical Areas Program 1983b	Newcastle		109											
31	Maine Critical Areas Program 1983b	No. 3 Pond Hemlock	50.8												
31	Maine Critical Areas Program 1983b	Ocean Park White Pine - Hemlock	71	69											
31	Maine Critical Areas Program 1983b	Pine Stream Flowage		114	33										
31	Maine Critical Areas Program 1983b	Pleasant Lake Hemlock	46-66 [10]	46-66 [10]											
31	Maine Critical Areas Program 1983b	Prentiss Woods White Pine- Hemlock	63	66	61										
31	Maine Critical Areas Program 1983b	Sabao Lake Hemlock	61												
31	Maine Critical Areas Program 1983b	Thomas Point Hemlock	38												
31	Maine Critical Areas Program 1983b	Waldoboro Hemlock	102				66				25				
31	Maine Critical Areas Program 1983b	Wassataquoik Stream White Pine		107											
32	Meyer and Stevenson 1943	Dunham--Stands 13-16													
32	Meyer and Stevenson 1943	Larson--Stands 11-12													
32	Meyer and Stevenson 1943	McClure--Stand 1													
32	Meyer and Stevenson 1943	Ricketts--Stands 4-5													
32	Meyer and Stevenson 1943	Rightmeier--Stands 6-10													
32	Meyer and Stevenson 1943	Tionesta--Stands 17-26													
33	Milfred et al. 1967	Stand 10	39+	62+		39+									
33	Milfred et al. 1967	Stand 27	55+			55+									
33	Milfred et al. 1967	Stand 35	39+	62+		32+									
34	Mladenoff and Howell 1980	Gogebic Range	122			71	56								
35	Morey 1936a	Cook Forest													
35	Morey 1936a	Hearts Content--Beech-Hemlock												126.2	
35	Morey 1936a	Hearts Content--Hemlock													
36	Morey 1936b	Hearts Content	105	126			61		96	76	97		74		
37	Nichols 1913	Colebrook Forest		[11]										[12]	
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 1	90	85											
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 2	85												
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 3	105												
38	Nowacki and Abrams 1994	Alan Seeger--Stream Terrace 1	90	75											
38	Nowacki and Abrams 1994	Alan Seeger--Stream Terrace 2	85	65											
39	Nowak 1993	Tionesta--RNAOG1	102				69				89	25	84	BC-64 [13]	
39	Nowak 1993	Tionesta--RNAOG2	109			20	76				76	46	89	BC-81 [13]	
39	Nowak 1993	Tionesta--RNAOG3	117			91	69				81	91	102	BC-99 [13]	
40	Oosting and Billings 1939	Ravenel's Woods--Polycodium type													
40	Oosting and Billings 1939	Ravenel's Woods--Rhododendron type													
41	Oosting and Bourdeau 1955	Joyce Kilmer--Forest-Herb Type	40+												
41	Oosting and Bourdeau 1955	Joyce Kilmer--Forest-Rhododendron Type	45+												

(Table 63 continued on next page)

(Table 63 continued)

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm) Eastern Hemlock	E. White Pine	Red Spruce	Sugar Maple	Yellow Birch	N. White-Cedar	N. Red Oak	White Oak	Red Maple	White Ash	Am. Beech	Other	Canopy Gaps (%)
42	Pinette and Rowe 1987	East Pinnacles	94												
42	Pinette and Rowe 1987	Scraggly Lake	91												
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 3													
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 6													
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 8													
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 10													
44	Runkle 1982	Huyck Preserve													4.8
44	Runkle 1982	Joyce Kilmer Wilderness Area													17.3
44	Runkle 1982	Tionesta Scenic and Research Natural Areas													5.0
44	Runkle 1982	Woodbourne Forest and Wildlife Sanctuary													3.2
45	Runkle 1991	Huyck Preserve--1978													
45	Runkle 1991	Huyck Preserve--1986													
46	Schmalzer 1978	Doe Creek, Little Piney Creek, Obed River													
47	Scott 1984	South Manitou Island													
48	Scott and Murphy 1986	South Manitou Island						162							
49	Stearns 1949	T35N, R14E, Sections 18,30													
50	Stearns 1950	Gillen Refuge		102											
51	Tritton and Siccama 1990	Catlin Wood													
51	Tritton and Siccama 1990	Eastwoods													
51	Tritton and Siccama 1990	Heart's Content													
52	Tyrrell 1988a	Moose Lake Hemlocks	79			88	71	38							
53	Tyrrell 1988b	Patterson Hemlocks	80	82		61	53								
54	Tyrrell 1988c	Plum Lake Hemlocks	81			56	63								
55	Tyrrell 1989	Scott Lake - Shelp Lake	74	96			64	57							
56	Tyrrell and Crow 1994[15]	Argonne	60	79		56	50	42			28				5.1
56	Tyrrell and Crow 1994[15]	Escanaba	61			23	63				43				11.1
56	Tyrrell and Crow 1994[15]	Glimmerglass	70	63		24	57								12.9
56	Tyrrell and Crow 1994[15]	Helen	102			66	92	39			49				12.7
56	Tyrrell and Crow 1994[15]	High	44					31			55				4.0
56	Tyrrell and Crow 1994[15]	Holmboe	62	61			35	11			47				7.6
56	Tyrrell and Crow 1994[15]	Island	72			13	62	21			47				10.9
56	Tyrrell and Crow 1994[15]	Keego	59	47		25		28			23			66	3.3
56	Tyrrell and Crow 1994[15]	Kemp	64			61	80								3.1
56	Tyrrell and Crow 1994[15]	Laura	70	40		55	51				43				3.6
56	Tyrrell and Crow 1994[15]	Lois	98			58	78	58			39				5.9
56	Tyrrell and Crow 1994[15]	Memorial Grove	79			71	92	33			48			101	16.9
56	Tyrrell and Crow 1994[15]	Moose	62				98	44			40				14.1

(Table 63 continued on next page)

(Table 63 continued)

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm)												Canopy Gaps (%)
			Eastern Hemlock	E. White Pine	Red Spruce	Sugar Maple	Yellow Birch	N. White-Cedar	N. Red Oak	White Oak	Red Maple	White Ash	Am. Beech	Other	
56	Tyrrell and Crow 1994[15]	One Stone	67	56		46	67	17			33				3.5
56	Tyrrell and Crow 1994[15]	Outer Island	103	46		49	78	60			47				16.7
56	Tyrrell and Crow 1994[15]	Patterson	76	82		52	62				52				5.9
56	Tyrrell and Crow 1994[15]	Plum	71			61	71				38			82	6.0
56	Tyrrell and Crow 1994[15]	Popple	37	57		26	37				23				7.6
56	Tyrrell and Crow 1994[15]	Pukall	56	58		25	55	37			33			61	9.4
56	Tyrrell and Crow 1994[15]	Salsich	75	70		59	43				43				7.1
56	Tyrrell and Crow 1994[15]	Scott	80	95		28	65	38			41				5.5
56	Tyrrell and Crow 1994[15]	Sweeny	64			64	71				36			71	5.3
56	Tyrrell and Crow 1994[15]	Tucker	92			94	81				34			94	9.7
56	Tyrrell and Crow 1994[15]	Wabikon	50				29	23							4.6
56	Tyrrell and Crow 1994[15]	Woodland	62			66	29								13.1
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1965													
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1979													
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1983													
58	Whitney 1984	Hearts Content--Hemlock-1929													
58	Whitney 1984	Hearts Content--Hemlock-1978													
58	Whitney 1984	Hearts Content--Hemlock-Beech-1929													
58	Whitney 1984	Hearts Content--Hemlock-Beech-1978													
59	Widoff 1985	Big Reed Pond Reserve--Mixed Forest													

[1] Did not specify if big trees were in gorge or ridge area.

[2] Maximum diameters were interpreted from graph for HM-1 and HM-2 combined.

[3] All diameters are witness tree diameters.

[4] Maximum diameter of red pine - 76 cm, balsam fir - 41 cm, aspen - 36 cm.

[5] Average diameter of trees >3.8 cm was 20.3-25.4.

[6] Average diameter of trees >3.8 cm was 23.4.

[7] Average diameter of trees >3.8 cm was 20.8.

[8] Average diameter of trees >3.8 cm was 23.6.

[9] Maximum diameter (above root swell) of red spruce was 71 cm at 700 m, 65 cm at 900 m; maximum diameter of sugar maple was 63 cm at 700 m and it did not occur at 900 m; maximum diameter of yellow birch was 72 cm at 700 m, 32 cm at 900 m.

[10] Average diameter for eastern hemlock and eastern white pine was 46-66 cm.

[11] Stump diameter at height of 60 cm was 150 cm.

[12] Average diameter was 90 cm; species not specified.

[13] Maximum diameter of cucumbertree was 122 cm.

[14] BC, black cherry

[15] Maximum diameter data from Tyrrell (1991) and Tyrrell unpublished data.

Table 64.—*Density, basal area, volume, and minimum diameter measured for standing dead trees (snags) for conifer-northern hardwood old-growth study sites.*

Map Key	Source/Date	Stand	Standing Dead Trees (Snags) Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Snag Volume (m^3/ha)	Min Snag Diam (cm)
1	Allard and Leonard 1952	Cabin Mountain				
2	Baldwin 1951	Bradford				
3	Bard 1967	Mianus River Preserve--Gorge				
3	Bard 1967	Mianus River Preserve--Ridge				
4	Bieri and Anliot 1965	Cathedral State Park				
5	Boone 1983	Henstep Valley--Upper Section				
6	Busing 1989	Long Branch Cove--Upper Stand-1930's				
6	Busing 1989	Long Branch Cove--Upper Stand-1980's				
7	Busing and White 1993	Roaring Fork				
8	Carbonneau 1986a	HM-1 (Gibbs Brook)	100	7.4		10
8	Carbonneau 1986a	HM-2 (Williams)	238			10
9	Cogbill 1985	Big Reed Pond Reserve--Mixed Forest		3.8 [1]		unspecified
10	Conkling 1978	Corrina				
11	Dahir and Lorimer 1996	Porcupine Mountains--Presque Isle River				
11	Dahir and Lorimer 1996	Porcupine Mountains--Speakers Creek				
12	DeYoung 1979	Great Smoky Mtns--White Pine-Red Oak				
12	DeYoung 1979	Great Smoky Mtns--White Pine-White Oak				
13	Donahue 1954	Bear Creek Ravine--No Pine				
13	Donahue 1954	Bear Creek Ravine--With Pine				
14	Dunn et al 1983	Flambeau River				
15	Dunwiddie 1993	Bash Bish--A-Grinder Brook	25	1.1		10
15	Dunwiddie 1993	Bash Bish--B-Bash Bish Falls	70	5.4		10
15	Dunwiddie 1993	Cold River--A-Plots 2, 3, 4	43	2.2		10
15	Dunwiddie 1993	Cold River--B-Black Brook	30	5.1		10
15	Dunwiddie 1993	Cold River--D	75	9		10
15	Dunwiddie 1993	Cold River--E-Manning Brook-Plot 1	60	10.2		10
15	Dunwiddie 1993	Dunbar Brook--Plot 2	20	1.9		10
15	Dunwiddie 1993	Fife Brook--Plots 3, 4	55	5.2		10
15	Dunwiddie 1993	Mt. Everett--Glen Brook	50	2.9		10
15	Dunwiddie 1993	Mt. Greylock--Deer Hill	130	3.5		10
15	Dunwiddie 1993	Mt. Greylock--Money Brook-Plot 3	70	1.8		10
15	Dunwiddie 1993	Parsonage Brook	70	3.3		10
16	Elliott 1953	Missaukee				
17	Fassett 1944	Brule River Basin				
18	Foster 1988	Harvard Tract				
19	Frelich and Lorimer 1991	Huron Mountains				
19	Frelich and Lorimer 1991	Porcupine Mountains				

(Table 64 continued on next page)

(Table 64 continued)

Map Key	Source/Date	Stand	Standing Dead Trees (Snags) Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Snag Volume (m^3/ha)	Min Snag Diam (cm)
19	Frelich and Lorimer 1991	Sylvania				
19	Frelich and Lorimer 1991	23 stands in Upper Michigan	13			46
20	Gates and Nichols 1930	Pellston				
21	Halpin 1990	Ramsey's Draft--Quad 1	15	2.7 [2]		10
21	Halpin 1990	Ramsey's Draft--Quad 2	59	17 [2]		10
21	Halpin 1990	Ramsey's Draft--Quad 3	44	11.3 [2]		10
21	Halpin 1990	Ramsey's Draft--Quads 1-3	46	8.9 [2]		10
22	Hett and Loucks 1976	Gardner Dam				
22	Hett and Loucks 1976	Northwest Lake				
22	Hett and Loucks 1976	Pot Lake				
22	Hett and Loucks 1976	West Branch				
23	Hough 1936	East Tionesta				
24	Hough and Forbes 1943	Cook Forest				
24	Hough and Forbes 1943	East Tionesta Creek Valley				
24	Hough and Forbes 1943	Stand Near Hearts Content				
25	Leak 1985a	Bartlett Ridge				
25	Leak 1985a	Bartlett 19				
25	Leak 1985a	Bartlett 26				
26	Leak 1987a	Bartlett Ridge				
26	Leak 1987a	Bartlett 19				
27	Leak 1987b	Bartlett--bedrock				
27	Leak 1987b	Bartlett--dry compact till				
27	Leak 1987b	Bartlett--outwash				
27	Leak 1987b	Bartlett--wet compact till				
28	Leak and Graber 1974	Mt. Whiteface (The Bowl)				
29	Leverett 1988	Dunbar Brook				
30	Lutz 1930c	Hearts Content--Hemlock		0.88 [3]		10
30	Lutz 1930c	Hearts Content--Hemlock-Beech		3.8 [3]		10
31	Maine Critical Areas Program 1983b	Adams Pond Hemlock				
31	Maine Critical Areas Program 1983b	Bald Mountain				
31	Maine Critical Areas Program 1983b	Chesuncook Lake				
31	Maine Critical Areas Program 1983b	Farm Cove Mountain Hemlock				
31	Maine Critical Areas Program 1983b	Hollis White Pine - Hemlock				
31	Maine Critical Areas Program 1983b	Huston Brook				
31	Maine Critical Areas Program 1983b	Mattawamkeag River Hemlock				
31	Maine Critical Areas Program 1983b	Moosehorn Stream				
31	Maine Critical Areas Program 1983b	Mt. Christopher Hemlock				

(Table 64 continued on next page)

(Table 64 continued)

Map Key	Source/Date	Stand	Standing Dead Trees (Snags) Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Snag Volume (m^3/ha)	Min Snag Diam (cm)
31	Maine Critical Areas Program 1983b	Newcastle				
31	Maine Critical Areas Program 1983b	No. 3 Pond Hemlock				
31	Maine Critical Areas Program 1983b	Ocean Park White Pine - Hemlock				
31	Maine Critical Areas Program 1983b	Pine Stream Flowage				
31	Maine Critical Areas Program 1983b	Pleasant Lake Hemlock				
31	Maine Critical Areas Program 1983b	Prentiss Woods White Pine- Hemlock				
31	Maine Critical Areas Program 1983b	Sabao Lake Hemlock				
31	Maine Critical Areas Program 1983b	Thomas Point Hemlock				
31	Maine Critical Areas Program 1983b	Waldoboro Hemlock				
31	Maine Critical Areas Program 1983b	Wassataquoik Stream White Pine				
32	Meyer and Stevenson 1943	Dunham--Stands 13-16				
32	Meyer and Stevenson 1943	Larson--Stands 11-12				
32	Meyer and Stevenson 1943	McClure--Stand 1				
32	Meyer and Stevenson 1943	Ricketts--Stands 4-5				
32	Meyer and Stevenson 1943	Rightmeier--Stands 6-10				
32	Meyer and Stevenson 1943	Tionesta--Stands 17-26				
33	Milfred et al. 1967	Stand 10				
33	Milfred et al. 1967	Stand 27				
33	Milfred et al. 1967	Stand 35				
34	Mladenoff and Howell 1980	Gogebic Range				
35	Morey 1936a	Cook Forest		13.6		10
35	Morey 1936a	Hearts Content--Beech-Hemlock				
35	Morey 1936a	Hearts Content--Hemlock				
36	Morey 1936b	Hearts Content				
37	Nichols 1913	Colebrook Forest				
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 1				
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 2				
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 3				
38	Nowacki and Abrams 1994	Alan Seeger--Stream Terrace 1				
38	Nowacki and Abrams 1994	Alan Seeger--Stream Terrace 2				
39	Nowak 1993	Tionesta--RNAOG1	134	}4.6 [4]	}36.3 [4]	7.6 [5]
39	Nowak 1993	Tionesta--RNAOG2	37	}	}	7.6 [5]
39	Nowak 1993	Tionesta--RNAOG3	98	}	}	7.6 [5]
40	Oosting and Billings 1939	Ravenel's Woods--Polycodium type				
40	Oosting and Billings 1939	Ravenel's Woods--Rhododendron type				
41	Oosting and Bourdeau 1955	Joyce Kilmer--Forest-Herb Type				
41	Oosting and Bourdeau 1955	Joyce Kilmer--Forest-Rhododendron Type				

(Table 64 continued on next page)

(Table 64 continued)

Map Key	Source/Date	Stand	Standing Dead Trees (Snags) Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Snag Volume (m^3/ha)	Min Snag Diam (cm)
42	Pinette and Rowe 1987	East Pinnacles				
42	Pinette and Rowe 1987	Scraggly Lake				
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 3				
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 6				
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 8				
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 10				
44	Runkle 1982	Huyck Preserve				
44	Runkle 1982	Joyce Kilmer Wilderness Area				
44	Runkle 1982	Tionesta Scenic and Research Natural Areas				
44	Runkle 1982	Woodbourne Forest and Wildlife Sanctuary				
45	Runkle 1991	Huyck Preserve--1978	54			11
45	Runkle 1991	Huyck Preserve--1986	74			11
46	Schmalzer 1978	Doe Creek, Little Piney Creek, Obed River				
47	Scott 1984	South Manitou Island	33.3+			2.54
48	Scott and Murphy 1986	South Manitou Island				
49	Stearns 1949	T35N, R14E, Sections 18,30				
50	Stearns 1950	Gillen Refuge				
51	Tritton and Siccama 1990	Catlin Wood	40	4.5		10
51	Tritton and Siccama 1990	Eastwoods	67	4.1		10
51	Tritton and Siccama 1990	Heart's Content	49	6.7		10
52	Tyrrell 1988a	Moose Lake Hemlocks	38	3.5		10
53	Tyrrell 1988b	Patterson Hemlocks	70	0.9		10
54	Tyrrell 1988c	Plum Lake Hemlocks	52	3.5		10
55	Tyrrell 1989	Scott Lake - Shelp Lake	48	7		10
56	Tyrrell and Crow 1994	Argonne	93	3.9	42.3	10
56	Tyrrell and Crow 1994	Escanaba	63	2.6	20.8	10
56	Tyrrell and Crow 1994	Glimmerglass	97	8.2	99.1	10
56	Tyrrell and Crow 1994	Helen	60	9.6	95.1	10
56	Tyrrell and Crow 1994	High	140	3.8	39.5	10
56	Tyrrell and Crow 1994	Holmboe	107	4.6	51.8	10
56	Tyrrell and Crow 1994	Island	40	1.6	18.6	10
56	Tyrrell and Crow 1994	Keego	100	6.5	91.5	10
56	Tyrrell and Crow 1994	Kemp	69	7	70.8	10
56	Tyrrell and Crow 1994	Laura	49	2	14.3	10
56	Tyrrell and Crow 1994	Lois	62	6.7	50.9	10
56	Tyrrell and Crow 1994	Memorial Grove	34	6.3	65.9	10
56	Tyrrell and Crow 1994	Moose	37	5.7	41.9	10

(Table 64 continued on next page)

(Table 64 continued)

			Standing Dead Trees (Snags)			
Map Key	Source/Date	Stand	Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Snag Volume (m^3/ha)	Min Snag Diam (cm)
56	Tyrrell and Crow 1994	One Stone	111	8.5	104	10
56	Tyrrell and Crow 1994	Outer Island	85	11.4	117.5	10
56	Tyrrell and Crow 1994	Patterson	76	9.4	109.3	10
56	Tyrrell and Crow 1994	Plum	79	3.5	80.7	10
56	Tyrrell and Crow 1994	Popple	127	5.2	59.7	10
56	Tyrrell and Crow 1994	Pukall	89	4.4	73.8	10
56	Tyrrell and Crow 1994	Salsich	102	7.5	74.9	10
56	Tyrrell and Crow 1994	Scott	40	3.8	31.4	10
56	Tyrrell and Crow 1994	Sweeny	44	3.2	35	10
56	Tyrrell and Crow 1994	Tucker	36	4.5	62.5	10
56	Tyrrell and Crow 1994	Wabikon	180	7.2	59.2	10
56	Tyrrell and Crow 1994	Woodland	70	9.4	153.5	10
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1965				
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1979				
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1983				
58	Whitney 1984	Hearts Content--Hemlock-1929				
58	Whitney 1984	Hearts Content--Hemlock-1978				
58	Whitney 1984	Hearts Content--Hemlock-Beech-1929				
58	Whitney 1984	Hearts Content--Hemlock-Beech-1978				
59	Widoff 1985	Big Reed Pond Reserve--Mixed Forest	91			10

[1] Snags are spruce or fir only.

[2] Basal area of "decadent" trees was estimated from graph to be: Quad 1--0.2 m^2/ha; Quad 2--2.0 m^2/ha; Quad 3--9 m^2/ha; and Quad 4--8 m2/ha.

[3] Snag values do not include additional dead trees that had been removed.

[4] Average for old-growth sites.

[5] Snags were defined as >1.4 m tall.

Table 65.—*Density, volume, and minimum diameter measured for fallen dead trees (logs) and the total volume of coarse woody debris (snags and logs) for conifer-northern hardwood old-growth study sites.*

Map Key	Source/Date	Stand	Fallen Dead Trees (Logs)			Total
			Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)	CWD Volume (m^3/ha)
1	Allard and Leonard 1952	Cabin Mountain				
2	Baldwin 1951	Bradford				
3	Bard 1967	Mianus River Preserve--Gorge				
3	Bard 1967	Mianus River Preserve--Ridge				
4	Bieri and Anliot 1965	Cathedral State Park				
5	Boone 1983	Henstep Valley--Upper Section				
6	Busing 1989	Long Branch Cove--Upper Stand-1930's				
6	Busing 1989	Long Branch Cove--Upper Stand-1980's				
7	Busing and White 1993	Roaring Fork				
8	Carbonneau 1986a	HM-1 (Gibbs Brook)	200		10	
8	Carbonneau 1986a	HM-2 (Williams)	288		10	
9	Cogbill 1985	Big Reed Pond Reserve--Mixed Forest				
10	Conkling 1978	Corrina				
11	Dahir and Lorimer 1996	Porcupine Mountains--Presque Isle River				
11	Dahir and Lorimer 1996	Porcupine Mountains--Speakers Creek				
12	DeYoung 1979	Great Smoky Mtns--White Pine-Red Oak				
12	DeYoung 1979	Great Smoky Mtns--White Pine-White Oak				
13	Donahue 1954	Bear Creek Ravine--No Pine				
13	Donahue 1954	Bear Creek Ravine--With Pine				
14	Dunn et al 1983	Flambeau River				
15	Dunwiddie 1993	Bash Bish--A-Grinder Brook				
15	Dunwiddie 1993	Bash Bish--B-Bash Bish Falls				
15	Dunwiddie 1993	Cold River--A-Plots 2, 3, 4				
15	Dunwiddie 1993	Cold River--B-Black Brook				
15	Dunwiddie 1993	Cold River--D				
15	Dunwiddie 1993	Cold River--E-Manning Brook-Plot 1				
15	Dunwiddie 1993	Dunbar Brook--Plot 2				
15	Dunwiddie 1993	Fife Brook--Plots 3, 4				
15	Dunwiddie 1993	Mt. Everett--Glen Brook				
15	Dunwiddie 1993	Mt. Greylock--Deer Hill				
15	Dunwiddie 1993	Mt. Greylock--Money Brook-Plot 3				
15	Dunwiddie 1993	Parsonage Brook				
16	Elliott 1953	Missaukee				
17	Fassett 1944	Brule River Basin				
18	Foster 1988	Harvard Tract				
19	Frelich and Lorimer 1991	Huron Mountains				
19	Frelich and Lorimer 1991	Porcupine Mountains				

(Table 65 continued on next page)

(Table 65 continued)

Map Key	Source/Date	Stand	Fallen Dead Trees (Logs) Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)	Total CWD Volume (m^3/ha)
19	Frelich and Lorimer 1991	Sylvania				
19	Frelich and Lorimer 1991	23 stands in Upper Michigan				
20	Gates and Nichols 1930	Pellston				
21	Halpin 1990	Ramsey's Draft--Quad 1		307.0	20	
21	Halpin 1990	Ramsey's Draft--Quad 2		376.2	20	
21	Halpin 1990	Ramsey's Draft--Quad 3		124.4	20	
21	Halpin 1990	Ramsey's Draft--Quads 1-3		222.2	20	
22	Hett and Loucks 1976	Gardner Dam				
22	Hett and Loucks 1976	Northwest Lake				
22	Hett and Loucks 1976	Pot Lake				
22	Hett and Loucks 1976	West Branch				
23	Hough 1936	East Tionesta				
24	Hough and Forbes 1943	Cook Forest				
24	Hough and Forbes 1943	East Tionesta Creek Valley				
24	Hough and Forbes 1943	Stand Near Hearts Content				
25	Leak 1985a	Bartlett Ridge				
25	Leak 1985a	Bartlett 19				
25	Leak 1985a	Bartlett 26				
26	Leak 1987a	Bartlett Ridge				
26	Leak 1987a	Bartlett 19				
27	Leak 1987b	Bartlett--bedrock				
27	Leak 1987b	Bartlett--dry compact till				
27	Leak 1987b	Bartlett--outwash				
27	Leak 1987b	Bartlett--wet compact till				
28	Leak and Graber 1974	Mt. Whiteface (The Bowl)				
29	Leverett 1988	Dunbar Brook				
30	Lutz 1930c	Hearts Content--Hemlock				
30	Lutz 1930c	Hearts Content--Hemlock-Beech				
31	Maine Critical Areas Program 1983b	Adams Pond Hemlock				
31	Maine Critical Areas Program 1983b	Bald Mountain				
31	Maine Critical Areas Program 1983b	Chesuncook Lake				
31	Maine Critical Areas Program 1983b	Farm Cove Mountain Hemlock				
31	Maine Critical Areas Program 1983b	Hollis White Pine - Hemlock				
31	Maine Critical Areas Program 1983b	Huston Brook				
31	Maine Critical Areas Program 1983b	Mattawamkeag River Hemlock				
31	Maine Critical Areas Program 1983b	Moosehorn Stream				
31	Maine Critical Areas Program 1983b	Mt. Christopher Hemlock				

(Table 65 continued on next page)

(Table 65 continued)

Map Key	Source/Date	Stand	Fallen Dead Trees (Logs) Density of Logs (#/ha)	Fallen Dead Trees (Logs) Volume of Logs (m^3/ha)	Fallen Dead Trees (Logs) Min Diam Logs (cm)	Total CWD Volume (m^3/ha)
31	Maine Critical Areas Program 1983b	Newcastle				
31	Maine Critical Areas Program 1983b	No. 3 Pond Hemlock				
31	Maine Critical Areas Program 1983b	Ocean Park White Pine - Hemlock				
31	Maine Critical Areas Program 1983b	Pine Stream Flowage				
31	Maine Critical Areas Program 1983b	Pleasant Lake Hemlock				
31	Maine Critical Areas Program 1983b	Prentiss Woods White Pine- Hemlock				
31	Maine Critical Areas Program 1983b	Sabao Lake Hemlock				
31	Maine Critical Areas Program 1983b	Thomas Point Hemlock				
31	Maine Critical Areas Program 1983b	Waldoboro Hemlock				
31	Maine Critical Areas Program 1983b	Wassataquoik Stream White Pine				
32	Meyer and Stevenson 1943	Dunham--Stands 13-16				
32	Meyer and Stevenson 1943	Larson--Stands 11-12				
32	Meyer and Stevenson 1943	McClure--Stand 1				
32	Meyer and Stevenson 1943	Ricketts--Stands 4-5				
32	Meyer and Stevenson 1943	Rightmeier--Stands 6-10				
32	Meyer and Stevenson 1943	Tionesta--Stands 17-26				
33	Milfred et al. 1967	Stand 10				
33	Milfred et al. 1967	Stand 27				
33	Milfred et al. 1967	Stand 35				
34	Mladenoff and Howell 1980	Gogebic Range				
35	Morey 1936a	Cook Forest				
35	Morey 1936a	Hearts Content--Beech-Hemlock				
35	Morey 1936a	Hearts Content--Hemlock				
36	Morey 1936b	Hearts Content				
37	Nichols 1913	Colebrook Forest				
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 1				
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 2				
38	Nowacki and Abrams 1994	Alan Seeger--Stream Bottom 3				
38	Nowacki and Abrams 1994	Alan Seeger--Stream Terrace 1				
38	Nowacki and Abrams 1994	Alan Seeger--Stream Terrace 2				
39	Nowak 1993	Tionesta--RNAOG1		124.7[1]	7.6	}125.2[2]
39	Nowak 1993	Tionesta--RNAOG2		88.4[1]	7.6	}
39	Nowak 1993	Tionesta--RNAOG3		116.7[1]	7.6	}
40	Oosting and Billings 1939	Ravenel's Woods--Polycodium type				
40	Oosting and Billings 1939	Ravenel's Woods--Rhododendron type				
41	Oosting and Bourdeau 1955	Joyce Kilmer--Forest-Herb Type				
41	Oosting and Bourdeau 1955	Joyce Kilmer--Forest-Rhododendron Type				

(Table 65 continued on next page)

(Table 65 continued)

			Fallen Dead Trees (Logs)			Total
Map Key	Source/Date	Stand	Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)	CWD Volume (m^3/ha)
42	Pinette and Rowe 1987	East Pinnacles				
42	Pinette and Rowe 1987	Scraggly Lake				
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 3				
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 6				
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 8				
43	Pregitzer and Barnes 1984	McCormick Natural Area--Site 10				
44	Runkle 1982	Huyck Preserve				
44	Runkle 1982	Joyce Kilmer Wilderness Area				
44	Runkle 1982	Tionesta Scenic and Research Natural Areas				
44	Runkle 1982	Woodbourne Forest and Wildlife Sanctuary				
45	Runkle 1991	Huyck Preserve--1978				
45	Runkle 1991	Huyck Preserve--1986				
46	Schmalzer 1978	Doe Creek, Little Piney Creek, Obed River				
47	Scott 1984	South Manitou Island	57+		2.54	
48	Scott and Murphy 1986	South Manitou Island				
49	Stearns 1949	T35N, R14E, Sections 18,30				
50	Stearns 1950	Gillen Refuge				
51	Tritton and Siccama 1990	Catlin Wood				
51	Tritton and Siccama 1990	Eastwoods				
51	Tritton and Siccama 1990	Heart's Content				
52	Tyrrell 1988a	Moose Lake Hemlocks	50	52.8	30	
53	Tyrrell 1988b	Patterson Hemlocks	56	70.0	30	
54	Tyrrell 1988c	Plum Lake Hemlocks	66	58.2	30	
55	Tyrrell 1989	Scott Lake - Shelp Lake	46	19.9	30	
56	Tyrrell and Crow 1994	Argonne		41.9	20	84.2
56	Tyrrell and Crow 1994	Escanaba		50.3	20	71.1
56	Tyrrell and Crow 1994	Glimmerglass		61.3	20	160.4
56	Tyrrell and Crow 1994	Helen		65.6	20	160.7
56	Tyrrell and Crow 1994	High		18.8	20	58.4
56	Tyrrell and Crow 1994	Holmboe		46.2	20	98.0
56	Tyrrell and Crow 1994	Island		84.7	20	103.3
56	Tyrrell and Crow 1994	Keego		21.4	20	112.8
56	Tyrrell and Crow 1994	Kemp		46.1	20	116.9
56	Tyrrell and Crow 1994	Laura		47.6	20	61.9
56	Tyrrell and Crow 1994	Lois		53.2	20	104.1
56	Tyrrell and Crow 1994	Memorial Grove		112.0	20	177.9
56	Tyrrell and Crow 1994	Moose		110.3	20	152.3

(Table 65 continued on next page)

(Table 65 continued)

			Fallen Dead Trees (Logs)			Total
Map Key	Source/Date	Stand	Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)	CWD Volume (m^3/ha)
56	Tyrrell and Crow 1994	One Stone		55.3	20	159.3
56	Tyrrell and Crow 1994	Outer Island		89.7	20	207.2
56	Tyrrell and Crow 1994	Patterson		58.6	20	167.9
56	Tyrrell and Crow 1994	Plum		55.9	20	136.6
56	Tyrrell and Crow 1994	Popple		11.4	20	71.0
56	Tyrrell and Crow 1994	Pukall		46.0	20	119.7
56	Tyrrell and Crow 1994	Salsich		80.2	20	155.0
56	Tyrrell and Crow 1994	Scott		23.7	20	55.0
56	Tyrrell and Crow 1994	Sweeny		38.1	20	73.1
56	Tyrrell and Crow 1994	Tucker		83.0	20	145.5
56	Tyrrell and Crow 1994	Wabikon		16.6	20	75.8
56	Tyrrell and Crow 1994	Woodland		50.5	20	204.0
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1965				
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1979				
57	Vogelmann et al. 1985	Camels Hump--Transition Forest-1983				
58	Whitney 1984	Hearts Content--Hemlock-1929				
58	Whitney 1984	Hearts Content--Hemlock-1978				
58	Whitney 1984	Hearts Content--Hemlock-Beech-1929				
58	Whitney 1984	Hearts Content--Hemlock-Beech-1978				
59	Widoff 1985	Big Reed Pond Reserve--Mixed Forest	235		10	

[1] Based on strip transects.

[2] Average for old-growth sites.

Table 66.—*Summary of attributes for old-growth conifer-northern hardwood stands (from Tables 58 through 65).*

Attribute	Range	References (Map Key)
Live Tree Density (#/ha)		
- Trees ≥ 2.5 cm d.b.h.	359 - 1998	3, 4, 13, 33, 39, 40, 41, 48, 50
- Trees ≥ 8.9 cm d.b.h.	519 - 934	22, 33
- Trees ≥ 10 cm d.b.h.	210 - 1173	8, 12, 14, 15, 19, 21, 35, 38, 39, 48, 51, 52, 53, 54, 55, 56, 59
- Trees ≥ 25 cm d.b.h.	175 - 301	35, 41, 49
- Trees ≥ 35 cm d.b.h.	80 - 200	15
- Trees ≥ 50 cm d.b.h.	7 - 82	4, 8, 21, 33, 39, 41, 52, 53, 54, 55, 56, 59
- Trees ≥ 70 cm d.b.h.	0 - 30	8, 33, 39, 52, 53, 54, 55, 56
- Not as specified above		2, 4, 5, 18, 21, 32, 34, 39, 45, 46, 49, 50
Live Tree Basal Area (m^2/ha)		
- Trees ≥ 2.5 cm d.b.h.	23.5 - 98.5	3, 39, 40, 41, 50
- Trees ≥ 10 cm d.b.h.	23.9 - 147.6	2, 8, 9, 12, 14, 15, 19, 21, 35, 38, 39, 42, 43, 51, 52, 53, 54, 55, 56
- Trees ≥ 35 cm d.b.h.	16.7 - 37.6	35
- Trees ≥ 50 cm d.b.h.	1.7 - 27.0	39, 56
- Trees ≥ 70 cm d.b.h.	0 - 13.5	39, 56
- Not as specified above		4, 6, 11, 18, 23, 25, 26, 27, 30, 34, 39, 46, 57
Tree or Stand Age (yr)		
Average Age by Species		
- Hemlock	151 - 275	19, 31, 37, 42, 56
- White Pine	181 - 232	24, 35
- Red Spruce	97 - 129	9, 42
- Sugar Maple	114 - 145	19, 42
Maximum Age by Species		
- Hemlock	140 - 536	1, 2, 3, 15, 20, 23, 24, 31, 33, 36, 37, 56
- White Pine	135 - 450	2, 10, 24, 30, 31, 35, 36, 50
- Red Spruce	100 - 309	9, 15, 31
- Sugar Maple	141 - 420	15, 20, 24
- Other		14, 19, 24, 27, 31, 36, 42

(Table 66 continued on next page)

(Table 66 continued)

Attribute	Range	References (Map Key)
Maximum Tree Diameter at Breast Height by Species (cm)		
- Hemlock	37 - 198	1, 3, 4, 8, 15, 20, 21, 22, 26, 29, 30, 31, 33, 34, 36, 38, 39, 41, 42, 52, 53, 54, 55, 56
- White Pine	40 - 132	2, 10, 13, 16, 17, 22, 26, 30, 31, 33, 36, 37, 38, 50, 53, 55, 56
- Red Spruce	33 - 71	8, 15, 26, 28, 31
- Sugar Maple	13 - 100	15, 20, 28, 29, 33, 34, 39, 52, 53, 54, 56
- Yellow Birch	29 - 98	15, 26, 28, 31, 34, 36, 39, 52, 53, 54, 55, 56
- Other		3, 8, 15, 21, 26, 29, 31, 35, 36, 39, 42, 52, 55, 56
Canopy Gaps (%)	3.1 - 17.3	6, 7, 19, 44, 56
Standing Dead Trees (Snags)		
Snag Density (#/ha)		
- Snags ≥ 7.6 cm d.b.h.	37 - 98	39
- Snags ≥ 10 cm d.b.h.	15 - 238	8, 15, 21, 30, 51, 52, 53, 54, 55, 56, 59
- Not as specified above		19, 45, 47
Snag Basal Area (m^2/ha)		
- Snags ≥ 7.6 cm d.b.h.	4.6	39
- Snags ≥ 10 cm d.b.h.	0.9 - 13.6	8, 15, 21, 30, 35, 51, 52, 53, 54, 55, 56
- Not as specified above		9
Snag Volume (m^3/ha)		
- Snags ≥ 7.6 cm d.b.h.	36.3	39
- Snags ≥ 10 cm d.b.h.	14.3 - 153.5	56

(Table 66 continued on next page)

(Table 66 continued)

Attribute	Range	References (Map Key)
Fallen Dead Trees (Logs)		
Density of Logs (#/ha)		
- Logs $\geq$ 10 cm d.b.h.	200 - 288	8, 59
- Logs $\geq$ 30 cm d.b.h.	46 - 66	52, 53, 54, 55
- Not as specified above		47
Volume of Logs (m^3/ha)		
- Logs $\geq$ 7.6 cm d.b.h.	88.4 - 124.7	39
- Logs $\geq$ 20.0 cm d.b.h.	11.4 - 376.2	21, 56
- Logs $\geq$ 30.0 cm d.b.h.	19.9 - 70.0	52, 53, 54, 55
Total Volume of Coarse Woody Debris (Snags and Logs) (m^3/ha)		
- Snags and Logs $\geq$ 7.6 cm	125.2	39
- Snags and Logs $\geq$ 20 cm	58.4 - 207.2	56

NORTHERN PINE FORESTS

COMMUNITY COMPOSITION

Forest Cover Types

The following Society of American Foresters (SAF) forest cover types (Eyre 1980) are included in the northern pine forest type group:

1 - jack pine
15 - red pine
21 - eastern white pine
[45 - pitch pine] not fully treated here

The following Combined Data Systems (CDS) forest cover types for the USDA Forest Service Eastern Region (USDA 1974) are included in northern pine forest type group:

1 - jack pine
2 - red pine
3 - white pine
9 - conifers
38 - pitch pine
48 - jack pine/oak
49 - red pine/oak

Species Composition

Northern pine forests can be divided into long-lived pines (eastern white pine (*Pinus strobus* L.) and red pine (*P. resinosa* Ait.)) and short-lived pines (jack pine (*P. banksiana* Lamb.) and

◀ *Large red pines in **Squirrel River State Natural Area.** Trees in this old-growth area in Oneida County, Wisconsin, were determined to be as old as 143 years, based on a total of 12 trees cored. See Duvall (1997). Photo 7/95 by Lucy Tyrrell.*

pitch pine (*P. rigida* Mill.)), although some sites may contain some of both groups. For example, although some forests are dominated by white pine and red pine, either solely or in mixtures, such stands may also include jack pine.

Pioneer species, such as bigtooth aspen (*Populus grandidentata* Michx.), quaking aspen (*P. tremuloides* Michx.), paper birch (*Betula papyrifera* Marsh.), and oaks (*Quercus* L.), are common associates. At later stages, balsam fir (*Abies balsamea* [L.] Mill.) red maple (*Acer rubrum* L.), white spruce (*Picea glauca* [Moench] Voss), red spruce (*P. rubens* Sarg.) (eastern portion of range), and other later successional species may occur. The shrub layer, if present, is usually characterized by ericaceous species.

PHYSICAL CONTEXT

Physiographic Provinces

Northern pine forests occur in the following physiographic provinces (after Fenneman 1938):

Coastal Plain	(northern portion of the Embayed section)
Piedmont	(northern portions of both sections)
Blue Ridge	(northern section)
Ridge and Valley	(Hudson-Champlain and Middle sections)
Appalachian Plateaus	(Allegheny Mountain, Unglaciated and Glaciated Allegeny Plateau, Catskill Mountains and Mohawk sections)
New England	(all sections)
Adirondack Central Lowland	(all sections except Osage)
Superior Upland	

Ecological Units

Northern pine forests occur in several divisions and provinces (see Keys *et al.* 1995):

200 Humid Temperate Domain
210 Warm Continental Division
212 Laurentian Mixed Forest Province
220 Hot Continental Division
221 Eastern Broadleaf Forest (Oceanic) Province
M210 Warm Continental Regime Mountains
M212 Adirondack-New England Mixed Forest-Coniferous Forest-Alpine Meadow Province
M220 Hot Continental Regime Mountains
M221 Central Appalachian Broadleaf Forest-Coniferous Forest-Meadow Province

Geographic Distribution

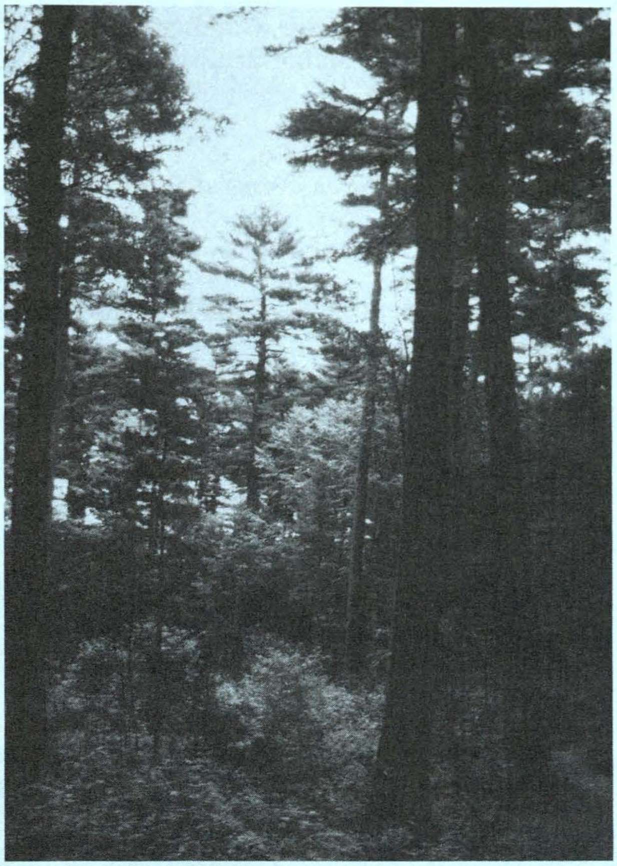
Northern pine forests occur primarily in the northern tier of Eastern States and extend southward along the Appalachians. Jack pine and/or pitch pine forests frequently occur on infertile outwash sands in the Upper Lake States, Mid-Atlantic and New England Regions. Fire has greatly influenced geographic distribution. For example, short-lived, highly flammable species, such as jack pine, occurred mainly in areas that burned hot and frequently (50-100 years), whereas long-lived, less flammable species, such as eastern white and red pine, predominated in areas that burned less intensely and frequently (130-160 years) (Heinselman 1973, 1981; Whitney 1986).

Soils

Most northern pine forests are found on glacial outwash, ice-contact deposits (*e.g.,* moraines), or thin-soiled, rock outcrops. In general, soils are dry to droughty, infertile, and coarse-textured. Eastern white pine can occur on dry, coarse-textured sites as well as mesic, medium-textured sites. Red pine forests are usually limited to dry, coarse-textured sites. Jack pine and pitch pine occur on xerophytic sites of infertile outwash sands.

Disturbance

Historically, these forests have been linked to large-scale disturbances, particularly fire (Chapman 1952, Clark 1990, Little 1974). Burning favors pine establishment by exposing mineral soil, reducing woody competition, and increasing light on the forest floor. Specific adaptations to fire by the dominant species include serotinous cones (jack pine), thick bark (eastern white pine and red pine), basal crooks, and the ability to sprout vegetatively (pitch pine).



▲ *White pines at **Bowdoin Pines**, in Maine. The 105-year-old stand includes large white pine in the overstory (the two trees in the foreground were 65.5 cm (right of center) and 67.5 cm (right) in diameter at breast height) and younger white and red pines and hardwoods in the understory. See Maine Critical Areas Program (1983b). Photo 7/92 by Lucy Tyrrell.*

Because of preferential cutting and changes in the disturbance regimes attributed to European settlement, many red and white pine stands have been either eliminated or have succeeded to other, later-successional forests (*e.g.*, conifer-northern hardwoods).

Representation of short-lived pines may have changed dramatically since pre-European settlement times due to European interference with natural disturbance regimes (*i.e.*, fire). Jack pine may have increased in the Upper Great Lakes Region due to preferential cutting of other species and increased fire frequency during European settlement (Cooper 1961). However, in other areas, reductions in fire frequency and intensity may have sharply decreased representation of jack or pitch pines.

RELATION TO OTHER FOREST TYPES

Barring frequent disturbances, pine forests on moist sites tend to succeed to hardwood types. However, this forest type group may be rather stable on xeric sites, even without disturbance. Due to logging and subsequent large-scale fires near the turn-of-the-century, many former eastern white pine stands have converted to other forest types, particularly hardwoods (Elliott 1953, Goodlett 1954).

Pine stands with a large hardwood component would fall into the conifer-northern hardwood forest type group. Composition favoring oaks would place the stand in a pine-oak forest type group.

STRUCTURAL CHARACTERISTICS OF OLD-GROWTH STANDS

Information about northern pine forests in an old-growth condition is included in Figure 10 and Tables 67 through 76.

SELECTED REPRESENTATIVE OLD-GROWTH STANDS

Connecticut

Cathedral Pines
(Davis 1993)

Indiana

Porter County White Pine Stand, Porter Co.

Iowa

Echo Valley, Fayette Co.

Eluffton Stand, Winneshiek Co.

Hesper Stand, Winneshiek Co.

Highlandville Stand, Winneshiek Co.

Pine Bluff, Winneshiek Co.

Pine Lake State Park, Hardin Co.

Twin Springs, Winneshiek Co.

Volga Stand, Clayton Co.

Waterville Stand, Allamakee Co.

White Pine Hollow State Park*, Dubuque Co.
(Davis 1993, Lindsey and Escobar 1976)

Wildcat Den State Park, Muscatine Co.

Yellow River Stand, Allamakee Co.

Maine

Attean Pond, Town of Attean, Somerset Co.
(Maine Critical Areas Program 1983a)

Baker Pond, Town of Caratunk, Somerset Co.
(Maine Critical Areas Program 1983b, 1985)

Bald Mountain, Washington Co.
(Maine Critical Areas Program 1983b, 1985)

Big Lake*, Washington Co.
(Maine Critical Areas Program 1983b, 1985)

Bowdoin Pines, Cumberland Co.
(Conkling 1978; Maine Critical Areas Program 1983b, 1985)

Bradstreet Jack Pine Natural Area, Moose River Valley
(Maine Critical Areas Program 1983a)

Bridgeton, Cumberland Co.
(Maine Critical Areas Program 1983b, 1985)

Cathedral Pines, Town of Eustis, Franklin Co.
(Maine Critical Areas Program 1983b, 1985)

Chesuncook Lake, Piscataquis Co.
(Maine Critical Areas Program 1983b, 1985)

Cliff Ridge, Piscataquis Co.
(Maine Critical Areas Program 1983b, 1985)

Cobbosseecontee, Kennebec Co.
(Conkling 1978; Maine Critical Areas Program 1983b, 1985)

Corrina Stand, Town of Corrina, Penobscot Co.
(Conkling 1978)

Debsconeag Lake*, T2-R10, Piscataquis Co.
(Maine Critical Areas Program 1983b, 1985)

Eagle Lake Stand, near Pillsbury Island Cove, Piscataquis Co.
(Conkling 1978)

Falmounth Interchange, Cumberland Co.
(Conkling 1978, Maine Critical Areas Program 1985)

French Island, Oxford Co.
(Maine Critical Areas Program 1983b, 1985)

Gero Island, Chesuncook Township, Piscataquis Co.
(Conkling 1978; Maine Critical Areas Program 1983b, 1985)

Goddard Farm, Aroostook Co.

Hollis Stand, Town of Hollis Center, York Co.
(Conkling 1978; Maine Critical Areas Program 1983b, 1985)

Huston Brook*, Dead River Township, Franklin Co.
(Maine Critical Areas Program 1983b, 1985)

Lobster Lake-Big Claw/Big Island*, Piscataquis Co.
(Maine Critical Areas Program 1983b, 1985)

May Mountain, Piscataquis Co.
(Pinette and Rowe 1987)

Moosehorn Stream, Piscataquis Co.
(Maine Critical Areas Program 1983b, 1985)

Mullen Woods, Town of Newport, Penobscot Co.
(Conkling 1978, Maine Critical Areas Program 1985)

Newcastle, Lincoln Co.
(Maine Critical Areas Program 1983b, 1985)

Number 5 Bog, Somerset Co.
(Maine Critical Areas Program 1983b, 1985)

Ordway Grove, Oxford Co.
(Maine Critical Areas Program 1985)

Pennesseewassee Lake Stand, Town of Norway, Oxford Co.
(Conkling 1978)

Pine Stream Flowage, Piscataquis Co.
(Maine Critical Areas Program 1983b)

Presumpscot River Stand, Town of Portland, Cumberland Co.
(Conkling 1978, Maine Critical Areas Program 1985)

Salsbury Cove Stand, Town of Bar Harbor, Hancock Co.
(Conkling 1978, Maine Critical Areas Program 1985)

Snowshoe Pond, Piscataquis Co.
(Pinette and Rowe 1987)

Soper Brook East, Piscataquis Co.
(Maine Critical Areas Program 1985)

Soper Brook West, Piscataquis Co.
(Maine Critical Areas Program 1983b, 1985)

Spencer Lake, Somerset Co.
(Maine Critical Areas Program 1983b, 1985)

Squa Pan Lake, Aroostook Co.
(Pinette and Rowe 1987)

The Hermitage, Piscataquis Co.
(Conkling 1978, Maine Critical Areas Program 1985)

The Narrows, Oxford Co.
(Conkling 1978; Maine Critical Areas Program 1983b, 1985)

The Pines-Sysladobsis Lake, Washington Co.
(Maine Critical Areas Program 1983b, 1985)

Vaughan Estate Stand, Town of Hallowell, Kennebec Co.
(Conkling 1978, Maine Critical Areas Program 1985)

Wassataquoik Stream, Penobscot Co.
(Maine Critical Areas Program 1983b, 1985)

Ziegler Campground Stand, Piscataquis Co.
(Conkling 1978, Maine Critical Areas Program 1985)

Massachusetts

Carlisle Pines State Forest

Walden Woods, Middlesex Co.

Michigan

Estivant Pines Nature Sanctuary*, Keweenaw Co.

Hartwick Pines State Park, Crawford Co.
(Collins 1958, Rose 1984)

Huron Mountain Club, Marquette Co.
(Davis 1993)

Indian River Pines, Hiawatha National Forest

McCormick Tract, Marquette Co.

Negro Creek White Pine, Lake Superior State Forest

Parcell Lakes White Pine, Lake Superior State Forest

Roscommon Red Pines, north of Saint Helen, Roscommon Co.
(Collins 1958)

Sylvania Wilderness Area*, Ottawa National Forest

◀ *Old-growth jack pine on the* ***Schoodic Peninsula*** *in Acadia National Park is stunted from coastal Maine winds and salt spray. See Maine Critical Areas Program (1983a). Photo 2/92 by Lucy Tyrrell.*

▶ *Red and white pines at* ***Murphy Pines****, on the Hiawatha National Forest, in Michigan. Based on stand records, this stand originated in 1824. Photo 6/92 by Lucy Tyrrell.*

Veteran's Memorial Park, Midland Co.

Minnesota

Boundary Waters Canoe Area Wilderness* (Lac La Croix Research Natural Area), Superior National Forest

Cathedral Grove, Lake Co.

Hovland Woods Scientific and Natural Area, Cook Co.
(Davis 1993)

Itasca Wilderness, Itasca State Park, Clearwater Co.

Lost 40 Pine Stand, Itasca County
(Duvall 1997)

Pine Point Research Natural Area, Chippewa National Forest
(Davis 1993)

Red Lake Peatland*, Beltrami Island/Pine Island State Forest
(Davis 1993)

New Hampshire

Big Pines Natural Area, Hemingway State Forest
(Davis 1993)

Bradford Pines, Merrimack Co.
(Baldwin 1951)

Lord Pines, Carroll Co.

Ordway Pines, Merrimack Co.

Pisgah Forest Blowdown, Cheshire Co.
(Davis 1993, Foster 1988, Henry and Swan 1974)

New York

Altona Flat Rock, Clinton Co.

Five Ponds Wilderness*, Adirondack State Park
(Davis 1993, Leopold *et al.* 1988)

Pine Orchard, Hamilton Co.
(Davis 1993)

North Carolina

Horsepasture River Gorge, Transylvania Co.
(Roe 1987)

Linville Gorge, Burke Co.
(Davis 1993, Roe 1987)

Thompson River Gorge, Transylvania Co.

Toxaway River Gorge, Transylvania Co.

Ohio

Mohican State Park, Ashland Co.

Pennsylvania

Alan Seeger Natural Area*, Rothrock State Forest
(Davis 1993, Nowacki and Abrams 1994)

Beechdale Hollow, near Meyerdale

Cook Forest State Park
(Davis 1993, Hough 1932, Hough and Forbes 1943)

Dingman Falls, near Dingman's Ferry
(Davis 1993)

Hearts Content Scenic Area*, Allegheny National Forest
(Morey 1936b)

Joyce Kilmer Natural Area*, Union Co.

Lower Jerry Run, Elk State Forest
(Erdman and Wiegman 1974)

Pack Saddle, near Fairhope
(Erdman and Wiegman 1974)

Reynolds Spring Natural Area, Tioga State Forest
(Erdman and Wiegman 1974)

Snyder-Middleswarth State Park
(Davis 1993)

*World's End State Park

Tennessee

Wright White Pine/Hemlock Stand, Johnson Co.

Vermont

Cambridge Pines State Natural Area, Lamoille Co.
(Davis 1993)

Canfield-Fisher Memorial Pines, Bennington Co.

Fisher-Scott Memorial Pines, Bennington Co.

Roy Mountain State Natural Area, Caledonia Co.
(Davis 1993)

Spectacle Pond State Natural Area, Essex Co.

Willard Mountain, Essex Co.
(Davis 1993)

West Virginia

Helmick Rock, South Branch Mountain, Hardy Co.
(Davis 1993)

Pine Knob, North Fork Branch Mountain, Pendleton Co.

Wisconsin

Annaton Pine Knob, Grant Co.

Baxter's Hollow, Sauk Co.
(Davis 1993, Lindsey and Escobar 1976, Maher 1988)

Bloch Pines, Marinette Co.

Brule River Conservation Area, Brule River State Forest
(Davis 1993, Maher 1988)

Cathedral Pines, Nicolet National Forest

Finnerud Pine Forest, Oneida Co.
(Lindsey and Escobar 1976, Davis 1993, Duvall 1997)

Flambeau River Preserve*
(Davis 1993, Dunn *et al.* 1983, Lindsey and Escobar 1976, Maher 1988)

Giant White Pine Grove, Nicolet National Forest
(Davis 1993)

Lampson Moraine Pines, Washburn Co.

Lucius Woods, Douglas Co.

New Hope Pines, Portage Co.

Ordway Pines, Douglas Co.

Pleasant Valley Pines, Grant Co.

Toft Point Scientific Area*, Door Co.
(Lindsey and Escobar 1976)

FOR ADDITIONAL INFORMATION

Additional references that pertain to northern pine forests but are not cited in tables or text are listed by forest type group in Appendix C.

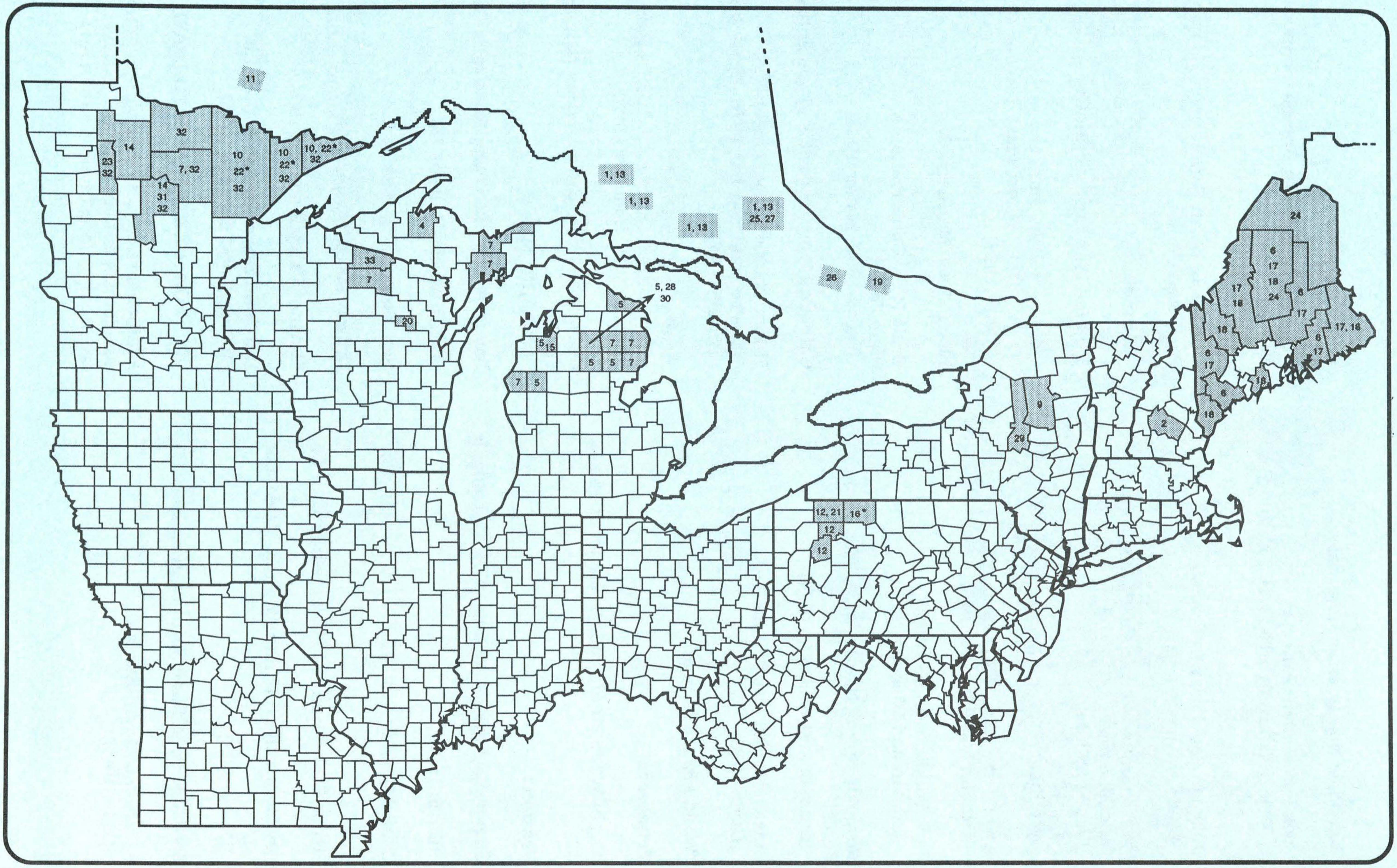

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Figure 10.—*General location of studies that provide stand structure information about old-growth northern pine forests. Shaded counties contain at least one study. Numbers correspond to the cited references listed under Map Key below and in Tables 67 through 76. States are indicated using two-letter postal abbreviations. An asterisk indicates that the county is probable but not certain. A question mark [?] indicates no county information is available, but the general location is given. Shaded areas in Canada were plotted from latitude and longitude given [or estimated from maps or information] by the authors in the cited reference.*

Map Key	Source/Date	State or Province	County
1	Arbex Forest Dev. Co. LTD. 1991	Ontario	46°55'N, 80°35'W 46°55'N, 82°30'W 47°12'N, 80°50'W 47°12'N, 83°50'W 47°34'N, 84°10'W
2	Baldwin 1951	NH	Merrimack
3	Bergman 1924	MN	(?) northern Minnesota
4	Bourdo 1961	MI	Baraga
5	Collins 1958	MI	Crawford, Grand Traverse, Lake, Ogemaw, Presque Isle, Roscommon
6	Conkling 1978	ME	Cumberland, Hancock, Oxford, Penobscot, Piscataquis
7	Duvall 1997	MI	Alcona, Alger, Delta, Iosco, Mason, Oscoda
		MN	Itasca
		WI	Oneida
8	Eyre and Zehngraff 1948	MN	(?) northern Minnesota
9	Graves 1899	NY	Hamilton
10	Heinselman 1973	MN	Cook, Lake, St. Louis
11	Holla and Knowles 1988	Ontario	49°05'N, 91°41'W
12	Hough and Forbes 1943	PA	Clarion, Forest, Warren
13	Iles 1990	Ontario	[47°34'N, 84°10'W] [47°12'N, 83°50'W] [46°55'N, 82°30'W] [46°55'N, 80°35'W] [47°12'N, 80°50'W] [47°10'N, 80°20'W]
14	Kittredge 1934	MN	Beltrami, Cass
15	Kittredge and Chittenden 1929	MI	Grand Traverse
16	Lutz and McComb 1935	PA	McKean*
17	Maine Critical Areas Program 1983a	ME	Hancock, Oxford, Penobscot, Piscataquis, Somerset, Washington
18	Maine Critical Areas Program 1983b	ME	Franklin, Lincoln, Piscataquis, Somerset, Washington, York
19	Methven 1973	Ontario	46°0'N, 77°26'W
20	Milfred et al. 1967	WI	Menominee
21	Morey 1936b	PA	Warren
22	Ohmann and Ream 1971b	MN	Cook*, Lake*, St. Louis*
23	Peet 1984	MN	Clearwater
24	Pinette and Rowe 1987	ME	Aroostook, Piscataquis
25	Quinby 1988a	Ontario	47°10'N, 80°20'W
26	Quinby 1988b	Ontario	[45°48'N, 78°30'W]
27	Quinby 1991	Ontario	47°10'N, 80°20'W
28	Robertson and Tiedje 1984	MI	Crawford
29	Roman 1980	NY	Herkimer
30	Rose 1984	MI	Crawford
31	Shirley 1932	MN	Cass
32	Stai and Mladenoff 1993	MN	Cass, Cook, Clearwater, Itasca, Koochiching, Lake, St. Louis
33	Stearns 1950	WI	Vilas

Table 67.—*Location, size, and elevation of northern pine old-growth study sites. Brackets around latitude and longitude indicate the values were estimated from information or maps in the reference cited.*

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 1	Ontario	}46°55'N, 82°30'W	} 1676[1]	} 450-569[1]
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 2	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 3	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 4	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 5	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 6	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 7	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 8	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 1	Ontario	} 47°12'N, 80°50'W	} 1129[2]	} 287-384[2]
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 2	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 3	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 4	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 1	Ontario	} 47°12'N, 83°50'W	} 737[3]	} 440-556[3]
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 2	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 3	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 4	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 5	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 6	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 7	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 2	Ontario	} 47°34'N, 84°10'W	} 907[4]	} 443-528[4]
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 3	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 8	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 1	Ontario	} 46°55'N, 80°35'W	} 623[5]	} 298-444[5]
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 2	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 3	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 4	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 5	Ontario	}	}	}
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 6	Ontario	}	}	}
2	Baldwin 1951	Bradford	NH	Merrimack	0.8	207
3	Bergman 1924	Areas in Northern Minnesota	MN	unspecified	small areas	unspecified
4	Bourdo 1961	Baraga County	MI	Baraga	8	unspecified
5	Collins 1958	East Crawford County	MI	Crawford	7	unspecified
5	Collins 1958	East Roscommon	MI	Roscommon	19	unspecified
5	Collins 1958	Hartwick Pines	MI	Crawford	20	unspecified
5	Collins 1958	Higgins Lake	MI	Roscommon	0.8	unspecified
5	Collins 1958	Houghton Lake	MI	Roscommon	8	unspecified
5	Collins 1958	Interlochen	MI	Grand Traverse	51	unspecified

(Table 67 continued on next page)

(Table 67 continued)

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
5	Collins 1958	Lake County	MI	Lake	1.2	unspecified
5	Collins 1958	Ogemaw County	MI	Ogemaw	1.2	unspecified
5	Collins 1958	Presque Isle	MI	Presque Isle	0.4	unspecified
5	Collins 1958	South Grayling	MI	Crawford	4.9	unspecified
6	Conkling 1978	Corrina	ME	Penobscot	1.6	unspecified
6	Conkling 1978	Eagle Lake	ME	Piscataquis	20	unspecified
6	Conkling 1978	Falmouth Interchange	ME	Cumberland	0.6	unspecified
6	Conkling 1978	Mullen Woods	ME	Penobscot	0.2	unspecified
6	Conkling 1978	Pennesseewassee Lake--Stand I	ME	Oxford	}1.6[6]	unspecified
6	Conkling 1978	Pennesseewassee Lake--Stand II	ME	Oxford	}	unspecified
6	Conkling 1978	Presumpscot River	ME	Cumberland	3.2	unspecified
6	Conkling 1978	Salsbury Cove	ME	Hancock	1.6	unspecified
7	Duvall 1997[7]	Finnerud (108/109)	WI	Oneida	24	unspecified
7	Duvall 1997[7]	Hoist Lakes--C-97, St-40 (85)	MI	Alcona	2.8	unspecified
7	Duvall 1997[7]	Holloway Road--C-101, St-4 (83)	MI	Oscoda	~5	unspecified
7	Duvall1997[7]	Indian River--C-18, St-26 (119)	MI	Alger	21	unspecified
7	Duvall 1997[7]	Lost 40--Oldest Stand (112)	MN	Itasca	unspecified	unspecified
7	Duvall 1997[7]	Lost 40--Younger Stand (121)	MN	Itasca	unspecified	unspecified
7	Duvall 1997[7]	Nordhouse Dunes (123)	MI	Mason	36	unspecified
7	Duvall 1997[7]	Squaw Creek--C-24, St-29 (110)	MI	Delta	9	unspecified
7	Duvall 1997[7]	Squirrel River (106)	WI	Oneida	~8	unspecified
7	Duvall 1997[7]	Tomahawk River (107)	WI	Oneida	~2	unspecified
7	Duvall 1997[7]	Valley Road--C-123, St-31 (82)	MI	Oscoda	6	unspecified
7	Duvall 1997[7]	Westlake--C-87, St-11 (111)	MI	Delta	2.8	unspecified
7	Duvall 1997[7]	Wilber--C-100, St-13 (84)	MI	Iosco	6	unspecified
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--1	MN	unspecified	unspecified	unspecified
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--2	MN	unspecified	unspecified	unspecified
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--3	MN	unspecified	unspecified	unspecified
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--1	MN	unspecified	unspecified	unspecified
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--2	MN	unspecified	unspecified	unspecified
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--3	MN	unspecified	unspecified	unspecified
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--1	MN	unspecified	unspecified	unspecified
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--2	MN	unspecified	unspecified	unspecified
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--3	MN	unspecified	unspecified	unspecified
9	Graves 1899	Round Pond Township 23	NY	Hamilton	unspecified	unspecified
10	Heinselman 1973	Amoeber Lake--Plot 11	MN	Lake	unspecified	unspecified
10	Heinselman 1973	Cash Lake--Plot 32	MN	Cook	unspecified	unspecified

(Table 67 continued on next page)

(Table 67 continued)

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
10	Heinselman 1973	Echo Trail--Plot 29	MN	St. Louis	unspecified	unspecified
10	Heinselman 1973	Ester Lake--Plot 15	MN	Lake	unspecified	unspecified
10	Heinselman 1973	Insula Lake--Plot 25	MN	St. Louis	unspecified	unspecified
10	Heinselman 1973	Keeley Creek--Plot 27	MN	St. Louis	unspecified	unspecified
10	Heinselman 1973	Moose River, S.--Plot 3	MN	St. Louis	unspecified	unspecified
10	Heinselman 1973	North Hegman Lake--Plot 28	MN	St. Louis	unspecified	unspecified
10	Heinselman 1973	Seagull Lake--Plot 6	MN	Cook	unspecified	unspecified
10	Heinselman 1973	Seagull Lake--Plot 7	MN	Cook	unspecified	unspecified
10	Heinselman 1973	Stand A-5, Gaskin Lake	MN	Cook	unspecified	unspecified
10	Heinselman 1973	Stand A-8, Boulder Bay, Lac La Croix	MN	St. Louis	unspecified	unspecified
11	Holla and Knowles 1988	Sandford Lake	Ontario	49°05'N, 91°41'W	35	unspecified
12	Hough and Forbes 1943	Cook Forest	PA	Clarion, Forest	unspecified	unspecified
12	Hough and Forbes 1943	East Tionesta Forest--Plot 8	PA	Warren	13	550
12	Hough and Forbes 1943	East Tionesta Forest--Plot 9	PA	Warren	unspecified	518
13	Iles 1990	Core 1/Tikamaganda Lake--White Pine	Ontario	[47°34'N, 84°10'W]	907	unspecified
13	Iles 1990	Core 2/Galloway Lake--White Pine	Ontario	[47°12'N, 83°50'W]	1067	unspecified
13	Iles 1990	Core 3/Bliss Lake--White Pine	Ontario	[47°12'N, 83°50'W]	501	unspecified
13	Iles 1990	Core 4/Quinn Lake--White Pine	Ontario	[47°12'N, 83°50'W]	737	unspecified
13	Iles 1990	Core 5/Bark Lake--Jack Pine	Ontario	[46°55'N, 82°30'W]	136	unspecified
13	Iles 1990	Core 5/Bark Lake--Red Pine	Ontario	[46°55'N, 82°30'W]	394	unspecified
13	Iles 1990	Core 5/Bark Lake--White Pine	Ontario	[46°55'N, 82°30'W]	1292	unspecified
13	Iles 1990	Core 6/Dave Lake--Jack Pine	Ontario	[46°55'N, 82°30'W]	17	unspecified
13	Iles 1990	Core 6/Dave Lake--Red Pine	Ontario	[46°55'N, 82°30'W]	21	unspecified
13	Iles 1990	Core 6/Dave Lake--White Pine	Ontario	[46°55'N, 82°30'W]	567	unspecified
13	Iles 1990	Core 7/Rushbrook Lake--Jack Pine	Ontario	[46°55'N, 82°30'W]	44	unspecified
13	Iles 1990	Core 7/Rushbrook Lake--White Pine	Ontario	[46°55'N, 82°30'W]	520	unspecified
13	Iles 1990	Core 8/Wolf Lake--Jack Pine	Ontario	[46°55'N, 80°35'W]	21	unspecified
13	Iles 1990	Core 8/Wolf Lake--Red Pine	Ontario	[46°55'N, 80°35'W]	727	unspecified
13	Iles 1990	Core 9/Obabika Lake--Red Pine	Ontario	[47°12'N, 80°50'W]	815	unspecified
13	Iles 1990	Core 9/Obabika Lake--White Pine	Ontario	[47°12'N, 80°50'W]	319	unspecified
13	Iles 1990	Core 10/Kokoko Bay--Red Pine	Ontario	[47°10'N, 80°20'W]	471	unspecified
13	Iles 1990	Core 10/Kokoko Bay--White Pine	Ontario	[47°10'N, 80°20'W]	221	unspecified
14	Kittredge 1934	Star Island--East Transitional Stand	MN	Beltrami, Cass	unspecified	unspecified
14	Kittredge 1934	Star Island--NW Windigo Jack Pine	MN	Beltrami, Cass	unspecified	unspecified
14	Kittredge 1934	Star Island--NW Windigo Norway Pine	MN	Beltrami, Cass	unspecified	unspecified
14	Kittredge 1934	Star Island--White Pine	MN	Beltrami, Cass	unspecified	unspecified
15	Kittredge and Chittenden 1929	Interlochen State Park	MI	Grand Traverse	unspecified	unspecified

(Table 67 continued on next page)

(Table 67 continued)

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
16	Lutz and McComb 1935	Ludlow	PA	McKean[8]	unspecified	unspecified
17	Maine Critical Areas Program 1983a	Attean Pond	ME	Somerset	12	unspecified
17	Maine Critical Areas Program 1983a	Big Island - Lobster Lake	ME	Piscataquis	4	unspecified
17	Maine Critical Areas Program 1983a	Bradstreet Jack Pine Natural Area	ME	Somerset	~800	unspecified
17	Maine Critical Areas Program 1983a	Cadillac Mountain	ME	Hancock	2.8	305
17	Maine Critical Areas Program 1983a	Dyer Neck	ME	Washington	0.9	72
17	Maine Critical Areas Program 1983a	First Debsconeag Lake	ME	Piscataquis	0.8	unspecified
17	Maine Critical Areas Program 1983a	Great Wass Island	ME	Washington	223	28
17	Maine Critical Areas Program 1983a	Holeb Pond	ME	Somerset	2	unspecified
17	Maine Critical Areas Program 1983a	Louse Island - Matagamon Lake	ME	Penobscot	4	unspecified
17	Maine Critical Areas Program 1983a	North of Schoodic Trail	ME	Hancock	4	unspecified
17	Maine Critical Areas Program 1983a	Passamagamet	ME	Piscataquis	1.6	610-1220
17	Maine Critical Areas Program 1983a	Schoodic Peninsula	ME	Hancock	121	up to 134
17	Maine Critical Areas Program 1983a	Umbagog Lake	ME	Oxford	4	unspecified
17	Maine Critical Areas Program 1983a	Wonsqueak	ME	Hancock	12	unspecified
18	Maine Critical Areas Program 1983b	Baker Pond	ME	Somerset	1.6	323-341
18	Maine Critical Areas Program 1983b	Bald Mountain	ME	Washington	0.4	91
18	Maine Critical Areas Program 1983b	Big Island - Lobster Lake	ME	Piscataquis	8	305
18	Maine Critical Areas Program 1983b	Cathedral Pines	ME	Franklin	89	354
18	Maine Critical Areas Program 1983b	Chesuncook Lake	ME	Piscataquis	18	323
18	Maine Critical Areas Program 1983b	Cliff Ridge	ME	Piscataquis	8	335-400
18	Maine Critical Areas Program 1983b	Debsconeag Lake	ME	Piscataquis	2	168-213
18	Maine Critical Areas Program 1983b	Gero Island	ME	Piscataquis	28	317
18	Maine Critical Areas Program 1983b	Hollis	ME	York	5	61
18	Maine Critical Areas Program 1983b	Huston Brook	ME	Somerset	unknown	323
18	Maine Critical Areas Program 1983b	Moosehorn Stream	ME	Piscataquis	10	372
18	Maine Critical Areas Program 1983b	Newcastle	ME	Lincoln	2.4	6
18	Maine Critical Areas Program 1983b	No. 5 Bog	ME	Somerset	10	366
18	Maine Critical Areas Program 1983b	Pine Stream Flowage	ME	Piscataquis	49	305
18	Maine Critical Areas Program 1983b	Spencer Lake	ME	Somerset	4	378
18	Maine Critical Areas Program 1983b	The Pines	ME	Washington	2.4	98
18	Maine Critical Areas Program 1983b	Wassataquoik Stream	ME	Penobscot	2	152
19	Methven 1973	Chalk River - Petewawa	Ontario	46°0'N, 77°26'W	unspecified	unspecified
20	Milfred et al. 1967	Stand 04	WI	Menominee	unspecified	unspecified
20	Milfred et al. 1967	Stand 10	WI	Menominee	unspecified	unspecified
20	Milfred et al. 1967	Stand 35	WI	Menominee	unspecified	unspecified
21	Morey 1936b	Hearts Content	PA	Warren	unspecified	unspecified

(Table 67 continued on next page)

(Table 67 continued)

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
22	Ohmann and Ream 1971b	Jack Pine (Oak)--11 Stands	MN	St. Louis, Cook, Lake [9]	unspecified	} 341-680 [10]
22	Ohmann and Ream 1971b	Jack Pine (Fir)--7 Stands	MN	St. Louis, Cook, Lake [9]	unspecified	}
22	Ohmann and Ream 1971b	Mixed Pine-Black Spruce--7 Stands	MN	St. Louis, Cook, Lake [9]	unspecified	}
22	Ohmann and Ream 1971b	Red Pine--4 Stands	MN	St. Louis, Cook, Lake [9]	unspecified	}
22	Ohmann and Ream 1971b	White Pine--6 Stands	MN	St. Louis, Cook, Lake [9]	unspecified	}
23	Peet 1984	Lake Itasca--1957	MN	Clearwater	unspecified	unspecified
23	Peet 1984	Lake Itasca--1983	MN	Clearwater	unspecified	unspecified
24	Pinette and Rowe 1987	May Mountain	ME	Piscataquis	8	335-396
24	Pinette and Rowe 1987	Snowshoe Pond	ME	Piscataquis	0.4	280-287
24	Pinette and Rowe 1987	Squa Pau Lake	ME	Aroostook	16	226
25	Quinby 1988a	Temagami--Wakimika Triangle Area	Ontario	47°10'N, 80°20'W	township	274-457
25	Quinby 1988a	Temagami--Red Pine	Ontario	47°10'N, 80°20'W	unspecified	unspecified
25	Quinby 1988a	Temagami--White Pine-Black Spruce	Ontario	47°10'N, 80°20'W	unspecified	unspecified
25	Quinby 1988a	Temagami--White Pine-Cedar	Ontario	47°10'N, 80°20'W	unspecified	unspecified
25	Quinby 1988a	Temagami--White Pine-Jack Pine	Ontario	47°10'N, 80°20'W	unspecified	unspecified
25	Quinby 1988a	Temagami--White Pine-Populus	Ontario	47°10'N, 80°20'W	unspecified	unspecified
25	Quinby 1988a	Temagami--White Pine-Red Pine	Ontario	47°10'N, 80°20'W	unspecified	unspecified
25	Quinby 1988a	Temagami--White Pine-White Birch	Ontario	47°10'N, 80°20'W	unspecified	unspecified
26	Quinby 1988b	Algonquin Park--Jack Pine Type	Ontario	[45°48'N, 78°30'W]	>6	unspecified
26	Quinby 1988b	Algonquin Park--Red Pine Type	Ontario	[45°48'N, 78°30'W]	>6	unspecified
26	Quinby 1988b	Algonquin Park--White Pine Type	Ontario	[45°48'N, 78°30'W]	>6	unspecified
27	Quinby 1991	Temagami--Wakimika Triangle Area	Ontario	47°10'N, 80°20'W	township	274-457
28	Robertson and Tiedje 1984	Hartwick Pines	MI	Crawford	100	unspecified
29	Roman 1980	Five Ponds Wilderness-Upland Conifer [11]	NY	Herkimer	20,000 [12]	490-750 [12]
29	Roman 1980	Five Ponds Wilderness--Plot 5	NY	Herkimer	1-5	555
29	Roman 1980	Five Ponds Wilderness--Plot 17	NY	Herkimer	1-5	533
29	Roman 1980	Five Ponds Wilderness--Plot 52	NY	Herkimer	1-5	549
29	Roman 1980	Five Ponds Wilderness--Plot 64	NY	Herkimer	1-5	543
30	Rose 1984	Hartwick Pines	MI	Crawford	20	unspecified
31	Shirley 1932	Cass Lake/Pike Bay	MN	Cass	10 sections	unspecified
32	Stai and Mladenoff 1993	August Lake	MN	Lake	unspecified	unspecified
32	Stai and Mladenoff 1993	Bohall Lake	MN	Clearwater	unspecified	unspecified
32	Stai and Mladenoff 1993	Burns Lake	MN	Itasca	unspecified	unspecified
32	Stai and Mladenoff 1993	Coon Lake 20	MN	Itasca	unspecified	unspecified
32	Stai and Mladenoff 1993	Hegman Lake	MN	St. Louis	unspecified	unspecified
32	Stai and Mladenoff 1993	Loon Lake	MN	Cook	unspecified	unspecified
32	Stai and Mladenoff 1993	Lost 40	MN	Itasca	unspecified	unspecified

(Table 67 continued on next page)

(Table 67 continued)

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
32	Stai and Mladenoff 1993	Nicollet Trail	MN	Clearwater	unspecified	unspecified
32	Stai and Mladenoff 1993	Onigum	MN	Cass	unspecified	unspecified
32	Stai and Mladenoff 1993	Pine Point	MN	Cass	unspecified	unspecified
32	Stai and Mladenoff 1993	Sandwick Lake	MN	Itasca	unspecified	unspecified
32	Stai and Mladenoff 1993	Sewage Pond	MN	Clearwater	unspecified	unspecified
32	Stai and Mladenoff 1993	Snail Lake	MN	Clearwater	unspecified	unspecified
32	Stai and Mladenoff 1993	Trout Lake	MN	St. Louis	unspecified	unspecified
32	Stai and Mladenoff 1993	Twomey Williams Road	MN	Koochiching	unspecified	unspecified
32	Stai and Mladenoff 1993	Voyageur Island	MN	Cook	unspecified	unspecified
33	Stearns 1950	Gillen Refuge/Plum Lake	WI	Vilas	unspecified	unspecified

[1] Area and elevation range is for entire Bark Lake site.

[2] Area and elevation range is for entire Obabika Lake site.

[3] Area and elevation range is for entire Quinn Lake site.

[4] Area and elevation range is for entire Tikamaganda Lake site.

[5] Area and elevation range is for entire Wolf Lake site.

[6] Area of both stands combined.

[7] Also unpublished data from Jeanette Rollinger, Matthew Duvall, and Lucy Tyrrell.

[8] County is unspecified, however, the town of Ludlow is in McKean County.

[9] Stands for entire study were located in these 3 counties; however, stands for each forest type may or may not be in all three.

[10] Elevational range for Boundary Waters.

[11] Average of 4 upland conifer stands.

[12] Entire Wilderness is this size and elevation; upland conifer stands were 1-5 ha in size.

Table 68.—*Criteria used by sources to identify old-growth stands, and information about stand composition of northern pine old-growth study sites. Species of pine are: JP, jack pine; RP, red pine; and WP, eastern white pine.*

Map Key	Source/Date	Stand	Species of Pine	Criteria for Stand Selection and Stand Composition
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 1	RP-WP	Core areas >500 ha, <5% disturbed, >140 yr; red pine (42%)-white pine (36%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 2	WP-RP	Core areas >500 ha, <5% disturbed, >140 yr; white pine (69%)-red pine (25%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 3	WP-RP	Core areas >500 ha, <5% disturbed, >140 yr; white pine (60%)-red pine (23%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 4	WP-RP	Core areas >500 ha, <5% disturbed, >140 yr; white pine (56%)-red pine (27%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 5	WP-RP [2]	Core areas >500 ha, <5% disturbed, >140 yr; white pine (35%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 6	WP-RP [2]	Core areas >500 ha, <5% disturbed, >140 yr; white pine (19%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 7	WP-RP [2]	Core areas >500 ha, <5% disturbed, >140 yr; white pine (56%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 8	WP-RP [2]	Core areas >500 ha, <5% disturbed, >140 yr; white pine (28%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 1	RP-WP	Core areas >500 ha, <5% disturbed, >140 yr; red pine (22%)-white pine (17%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 2	WP-RP	Core areas >500 ha, <5% disturbed, >140 yr; white pine (40%)-red pine (28%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 3	RP-WP	Core areas >500 ha, <5% disturbed, >140 yr; red pine (42%)-white pine (22%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 4	WP-RP	Core areas >500 ha, <5% disturbed, >140 yr; white pine (19%)-red pine (11%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 1	WP	Core areas >500 ha, <5% disturbed, >140 yr; white pine (62%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 2	WP-RP [2]	Core areas >500 ha, <5% disturbed, >140 yr; white pine (38%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 3	WP-RP [2]	Core areas >500 ha, <5% disturbed, >140 yr; white pine (39%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 4	WP-RP [2]	Core areas >500 ha, <5% disturbed, >140 yr; white pine (31%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 5	WP	Core areas >500 ha, <5% disturbed, >140 yr; white pine (43%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 6	WP-RP	Core areas >500 ha, <5% disturbed, >140 yr; white pine (33%)-red pine (6%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 7	WP-RP [2]	Core areas >500 ha, <5% disturbed, >140 yr; white pine (81%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 2	WP	Core areas >500 ha, <5% disturbed, >140 yr; white pine (65%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 3	WP	Core areas >500 ha, <5% disturbed, >140 yr; white pine (33%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 8	WP	Core areas >500 ha, <5% disturbed, >140 yr; white pine (35%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 1	RP-WP-JP	Core areas >500 ha, <5% disturbed, >140 yr; red pine (67%)-white pine (14%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 2	RP-WP	Core areas >500 ha, <5% disturbed, >140 yr; red pine (55%)-white pine (25%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 3	RP-WP	Core areas >500 ha, <5% disturbed, >140 yr; red pine (46%)-white pine (30%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 4	RP-WP	Core areas >500 ha, <5% disturbed, >140 yr; red pine (59%)-white pine (15%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 5	WP	Core areas >500 ha, <5% disturbed, >140 yr; white pine (44%) [1]
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 6	RP-WP-JP	Core areas >500 ha, <5% disturbed, >140 yr; red pine (36%)-white pine (9%) [1]
2	Baldwin 1951	Bradford	WP [3]	Survived hurricane undisturbed; 150-200 yr; white pine (50% [4]-hemlock-beech
3	Bergman 1924	Areas in Northern Minnesota	RP-WP	Pine forest climax remaining after logging; white pine-red pine-fir-paper birch
4	Bourdo 1961	Baraga County	WP	
5	Collins 1958	East Crawford County	RP	Old growth; some salvage after windthrow; red pine (>80%) [5]
5	Collins 1958	East Roscommon	RP-WP	One of best examples of old red pine in primeval state; red pine (~83%)-white pine (17%) [5]
5	Collins 1958	Hartwick Pines	WP-RP	Old growth; white pine (42%)-hemlock (28%)-red pine (14%)-maple [5]
5	Collins 1958	Higgins Lake	RP	Old growth; red pine (~98%)
5	Collins 1958	Houghton Lake	RP-WP	Old growth; light cutting of red pine; red pine (78%)-white pine (6%) [5]
5	Collins 1958	Interlochen	RP-WP	Old growth; widely spaced red (26%) and white (22%) pine, and oaks [5]

(Table 68 continued on next page)

(Table 68 continued)

Map Key	Source/Date	Stand	Species of Pine	Criteria for Stand Selection and Stand Composition
5	Collins 1958	Lake County	RP-WP	Old growth; uncut, cottages in stand; red pine (61%)-white pine (34%)[5]
5	Collins 1958	Ogemaw County	RP	Old growth; selective cutting 10-15 yr ago; red pine (~98%) [5]
5	Collins 1958	Presque Isle	RP	Old growth; red pine (~100%) [5]
5	Collins 1958	South Grayling	RP	Old growth trees remnant of past logging and fires; red pine (~100%) [5]
6	Conkling 1978	Corrina	WP	Old growth [6]; probably windthrow origin
6	Conkling 1978	Eagle Lake	WP	Old growth [6]; probably windthrow origin
6	Conkling 1978	Falmouth Interchange	WP	Old growth [6]; >1 acre; natural origin;white pine-hemlock
6	Conkling 1978	Mullen Woods	WP	Old growth [6]; probably windthrow origin
6	Conkling 1978	Pennesseewassee Lake--Stand I	WP	Old growth [6];eastern white pine
6	Conkling 1978	Pennesseewassee Lake--Stand II	WP	Old growth [6]; eastern white pine
6	Conkling 1978	Presumpscot River	WP	Old growth [6]; natural origin; white pine-hemlock
6	Conkling 1978	Salsbury Cove	WP	Old growth [6]; probably old field origin
7	Duvall 1997	Finnerud (108/109)	RP-WP	See notes; state significant old growth; red pine (72-74%)-red oak-red maple-white pine
7	Duvall 1997	Hoist Lakes--C-97, St-40 (85)	RP-JP	See notes; unthinned; red pine (81%)-aspen (8%)-jack pine (4%)
7	Duvall 1997	Holloway Road--C-101, St-4 (83)	RP-JP	See notes; old stumps but no record of thinning; red pine (77%)-jack pine (8%)-red oak (8%)
7	Duvall 1997	Indian River--C-18, St-26 (119)	RP-WP-JP	Old growth [7]; unthinned, a few stumps; red pine (78%)-white pine (13%)-jack pine (8%)
7	Duvall 1997	Lost 40--Oldest Stand (112)	WP-RP	Old growth [7]; little human disturbance; white pine (45%)-red pine (35%)
7	Duvall 1997	Lost 40--Younger Stand (121)	RP-WP	Old growth [7]; little disturbance; fire ~1900; >100 yr; red pine (81%)-white pine (9%)
7	Duvall 1997	Nordhouse Dunes (123)	RP-JP-WP	Old growth [7]; part thinned; red pine (75%)-jack pine (6%)-red maple-white oak
7	Duvall 1997	Squaw Creek--C-24, St-29 (110)	RP-WP	Old growth [7]; some parts thinned; red pine (60%)-white pine (19%)-paper birch (7%)
7	Duvall 1997	Squirrel River (106)	RP-WP	Old growth [7]; only a few scattered stumps; >100 yr; red pine (80%)-white pine (10%)
7	Duvall 1997	Tomahawk River (107)	WP-RP	Old growth [7]; unlogged stand along river; white pine (56%)-red pine (40%)
7	Duvall 1997	Valley Road--C-123, St-31 (82)	RP	Old growth [7]; unthinned; red pine (93%)
7	Duvall 1997	Westlake--C-87, St-11 (111)	RP	Old growth [7]; fairly recent thinning/salvage; red pine (100%)
7	Duvall 1997	Wilber--C-100, St-13 (84)	RP-WP	Old growth [7]; unthinned; red pine (56%)-white pine (18%)-red maple (12%)
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--1	RP	Unmanaged; mostly red pine
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--2	RP	Unmanaged; mostly red pine
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--3	RP	Unmanaged; mostly red pine
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--1	RP	Unmanaged; mostly red pine
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--2	RP	Unmanaged; mostly red pine
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--3	RP	Unmanaged; mostly red pine
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--1	RP	Unmanaged; mostly red pine
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--2	RP	Unmanaged; mostly red pine
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--3	RP	Unmanaged; mostly red pine
9	Graves 1899	Round Pond Township 23	WP	Old white pine scattered through forests of Adirondacks
10	Heinselman 1973	Amoeber Lake--Plot 11	JP	Virgin; >100 yr old; jack pine-black spruce
10	Heinselman 1973	Cash Lake--Plot 32	JP	Virgin; >100 yr old; black spruce-jack pine-balsam fir

(Table 68 continued on next page)

(Table 68 continued)

Map Key	Source/Date	Stand	Species of Pine	Criteria for Stand Selection and Stand Composition
10	Heinselman 1973	Echo Trail--Plot 29	JP	Virgin; >100 yr old; jack pine-balsam fir-paper birch
10	Heinselman 1973	Ester Lake--Plot 15	JP	Virgin; >100 yr old; jack pine-black spruce
10	Heinselman 1973	Insula Lake--Plot 25	JP	Virgin; >100 yr old; jack pine-paper birch
10	Heinselman 1973	Keeley Creek--Plot 27	JP	Virgin; >100 yr old; jack pine-balsam fir
10	Heinselman 1973	Moose River, S.--Plot 3	JP	Virgin; >100 yr old; jack pine-black spruce
10	Heinselman 1973	North Hegman Lake--Plot 28	JP	Virgin; >100 yr old; jack pine-black spruce
10	Heinselman 1973	Seagull Lake--Plot 6	JP	Virgin; >100 yr old; jack pine-red pine-black spruce-paper birch
10	Heinselman 1973	Seagull Lake--Plot 7	JP	Virgin; >100 yr old; jack pine-black spruce-paper birch
10	Heinselman 1973	Stand A-5, Gaskin Lake	WP	Virgin; >100 yr old; white pine-balsam fir-white spruce
10	Heinselman 1973	Stand A-8, Boulder Bay, Lac La Croix	RP	Virgin; >100 yr old; red pine-white pine-black spruce
11	Holla and Knowles 1988	Sandford Lake	WP-RP	Undisturbed; 140 yr white pine (80%)-red pine, with 80-yr black spruce-paper birch
12	Hough and Forbes 1943	Cook Forest	WP	Virgin; white pine-hemlock
12	Hough and Forbes 1943	East Tionesta Forest--Plot 8	WP	Virgin forest; burned in 1644; white pine-hemlock
12	Hough and Forbes 1943	East Tionesta Forest--Plot 9	WP	Virgin forest; burned in 1644; 1811 tornado; white pine-chestnut
13	Iles 1990	Core 1/Tikamaganda Lake--White Pine	WP	Core areas >500 ha white and/or red pine >140 yr; <5% disturbed
13	Iles 1990	Core 2/Galloway Lake--White Pine	WP	Core areas >500 ha white and/or red pine >140 yr; <5% disturbed
13	Iles 1990	Core 3/Bliss Lake--White Pine	WP	Core areas >500 ha white and/or red pine >140 yr; <5% disturbed
13	Iles 1990	Core 4/Quinn Lake--White Pine	WP	Core areas >500 ha white and/or red pine >140 yr; <5% disturbed
13	Iles 1990	Core 5/Bark Lake--Jack Pine	JP	Core areas >500 ha white and/or red pine >140 yr; <5% disturbed
13	Iles 1990	Core 5/Bark Lake--Red Pine	RP	Core areas >500 ha white and/or red pine >140 yr; <5% disturbed
13	Iles 1990	Core 5/Bark Lake--White Pine	WP	Core areas >500 ha white and/or red pine >140 yr; <5% disturbed
13	Iles 1990	Core 6/Dave Lake--Jack Pine	JP	Core areas >500 ha white and/or red pine >140 yr; <5% disturbed
13	Iles 1990	Core 6/Dave Lake--Red Pine	RP	Core areas >500 ha white and/or red pine >140 yr; <5% disturbed
13	Iles 1990	Core 6/Dave Lake--White Pine	WP	Core areas >500 ha white and/or red pine >140 yr; <5% disturbed
13	Iles 1990	Core 7/Rushbrook Lake--Jack Pine	JP	Core areas >500 ha white and/or red pine >140 yr; <5% disturbed
13	Iles 1990	Core 7/Rushbrook Lake--White Pine	WP	Core areas >500 ha white and/or red pine >140 yr; <5% disturbed
13	Iles 1990	Core 8/Wolf Lake--Jack Pine	JP	Core areas >500 ha white and/or red pine >140 yr; <5% disturbed
13	Iles 1990	Core 8/Wolf Lake--Red Pine	RP	Core areas >500 ha white and/or red pine >140 yr; <5% disturbed
13	Iles 1990	Core 9/Obabika Lake--Red Pine	RP	Core areas >500 ha white and/or red pine >140 yr; <5% disturbed
13	Iles 1990	Core 9/Obabika Lake--White Pine	WP	Core areas >500 ha white and/or red pine >140 yr; <5% disturbed
13	Iles 1990	Core 10/Kokoko Bay--Red Pine	RP	Core areas >500 ha white and/or red pine >140 yr; <5% disturbed
13	Iles 1990	Core 10/Kokoko Bay--White Pine	WP	Core areas >500 ha white and/or red pine >140 yr; <5% disturbed
14	Kittredge 1934	Star Island--East Transitional Stand	RP-WP	Least disturbed; transitional stand from red pine to white pine
14	Kittredge 1934	Star Island--NW Windigo Jack Pine	JP-RP-WP	Least disturbed by human activities or fire; jack pine ~100 yr
14	Kittredge 1934	Star Island--NW Windigo Norway Pine	RP	Least disturbed; red pine (98%)-white pine (2%) based on large trees
14	Kittredge 1934	Star Island--White Pine	WP	Least disturbed by human activities or fire; white pine
15	Kittredge and Chittenden 1929	Interlochen State Park	WP-RP	Old growth; overstory scattered white pine-red pine, understory oaks, other species

(Table 68 continued on next page)

(Table 68 continued)

Map Key	Source/Date	Stand	Species of Pine	Criteria for Stand Selection and Stand Composition
16	Lutz and McComb 1935	Ludlow	WP	Virgin stand; portions pure white pine
17	Maine Critical Areas Program 1983a	Attean Pond	JP	Undisturbed jack pine on 18 islands and mainland shoreline
17	Maine Critical Areas Program 1983a	Big Island - Lobster Lake	JP	Undisturbed; stands on shoreline; jack pine
17	Maine Critical Areas Program 1983a	Bradstreet Jack Pine Natural Area	JP-RP	Undisturbed; fire in 1888; jack pine (10-90%)-red spruce-black spruce-white birch
17	Maine Critical Areas Program 1983a	Cadillac Mountain	JP	Undisturbed; gnarled and stunted jack pine
17	Maine Critical Areas Program 1983a	Dyer Neck	JP	Undisturbed; two small areas of jack pine (60-70%)-white birch-red spruce
17	Maine Critical Areas Program 1983a	First Debsconeag Lake	JP	Several criteria; jack pine-northern white-cedar-red maple
17	Maine Critical Areas Program 1983a	Great Wass Island	JP	Undisturbed; largest area of jack pine (40-60%) stands in e. Maine
17	Maine Critical Areas Program 1983a	Holeb Pond	JP	Undisturbed; small area of jack pine along shoreline
17	Maine Critical Areas Program 1983a	Louse Island - Matagamon Lake	JP	Undisturbed; jack pine-red pine-white spruce-red oak[8]
17	Maine Critical Areas Program 1983a	North of Schoodic Trail	JP	Old age; jack pine (95%)
17	Maine Critical Areas Program 1983a	Passamagamet	JP	Undisturbed; shoreline jack pine-white-cedar
17	Maine Critical Areas Program 1983a	Schoodic Peninsula	JP	Old age[9]; extensive area of jack pine (80%)-red spruce-white-cedar-white birch
17	Maine Critical Areas Program 1983a	Umbagog Lake	JP	Undisturbed jack pine along rocky lakeshore
17	Maine Critical Areas Program 1983a	Wonsqueak	JP	Old age; jack pine
18	Maine Critical Areas Program 1983b	Baker Pond	RP-WP	Several criteria; undisturbed, a few stumps; red pine-red spruce-white pine
18	Maine Critical Areas Program 1983b	Bald Mountain	WP	Remnant old growth; white pine over younger red spruce-fir-maple
18	Maine Critical Areas Program 1983b	Big Island - Lobster Lake	RP-JP	Several criteria; little disturbance; red pine-jack pine
18	Maine Critical Areas Program 1983b	Cathedral Pines	RP	Selection cut of 1962, 5-acre thinned in 1980; some dead tree salvage[10]
18	Maine Critical Areas Program 1983b	Chesuncook Lake	WP	Old age; slight harvesting disturbance; white pine over spruce-fir
18	Maine Critical Areas Program 1983b	Cliff Ridge	RP-WP	Several criteria; undisturbed; red pine (80%)-white pine (20%)
18	Maine Critical Areas Program 1983b	Debsconeag Lake	RP-WP	Several criteria; undisturbed red pine-white pine-red spruce-hemlock
18	Maine Critical Areas Program 1983b	Gero Island	WP	Old growth; white pine (150-200 yr) over spruce-fir (75-100 yr)
18	Maine Critical Areas Program 1983b	Hollis	WP	Old growth; some removal of dead trees; white pine-hemlock
18	Maine Critical Areas Program 1983b	Huston Brook	WP	Several criteria; white pine-cedar-red spruce-balsam fir
18	Maine Critical Areas Program 1983b	Moosehorn Stream	WP	Old growth[11]; decayed stumps[12]; white pine (120-150 yr)-red spruce (93-130 yr)
18	Maine Critical Areas Program 1983b	Newcastle	WP	Natural old growth; white pine-red oak
18	Maine Critical Areas Program 1983b	No. 5 Bog	RP-JP	Several criteria; red pine-jack pine-red spruce[13]
18	Maine Critical Areas Program 1983b	Pine Stream Flowage	WP	Old growth, selectively cut decades ago; white pine-red spruce-balsam fir
18	Maine Critical Areas Program 1983b	Spencer Lake	WP	Large old pines; thinned, selectively logged; white pine-spruce-fir
18	Maine Critical Areas Program 1983b	The Pines	RP-WP	>250 yr; ice storm salvage in 1945; cabins in area; red pine-white pine
18	Maine Critical Areas Program 1983b	Wassataquoik Stream	WP	Remnant of natural old growth[14]; white pine within maple-beech
19	Methven 1973	Chalk River - Petewawa	RP-WP	Fire-origin stand ~90 yr old; red pine (59%)-white pine (25%)-white spruce
20	Milfred et al. 1967	Stand 04	WP	Large white pines ~350 yr; white pine-hemlock-hardwood
20	Milfred et al. 1967	Stand 10	WP	130-yr stand; white pine overstory dominant; white pine-hemlock-sugar maple
20	Milfred et al. 1967	Stand 35	WP	130-yr stand; white pine overstory dominant; white pine-hemlock
21	Morey 1936b	Hearts Content	WP	Virgin; hemlock-pine-hardwoods

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(Table 68 continued)

Map Key	Source/Date	Stand	Species of Pine	Criteria for Stand Selection and Stand Composition
22	Ohmann and Ream 1971b	Jack Pine (Oak)--11 Stands	JP	Post-fire stands, 60-105 yr old; jack pine (84%)-black spruce (4%) [15]
22	Ohmann and Ream 1971b	Jack Pine (Fir)--7 Stands	JP	Post-fire stands, relatively young; jack pine (71%)-black spruce (8%) [16]
22	Ohmann and Ream 1971b	Mixed Pine-Black Spruce--7 Stands	JP-RP-WP	Post-fire stands, 68-107 yr old; jack pine (43%)-black spruce (30%) [17]
22	Ohmann and Ream 1971b	Red Pine--4 Stands	RP-WP	Old, majestic stands; red pine (49%)-white pine (41%)
22	Ohmann and Ream 1971b	White Pine--6 Stands	WP-RP	Post fire stands 96-107 yr old [18]; white pine (72%)-red pine (10%)
23	Peet 1984	Lake Itasca--1957	WP	Large white pines (48% basal area) in sugar maple-basswood stand
23	Peet 1984	Lake Itasca--1983	WP	Large white pines (53% basal area) in sugar maple-basswood stand
24	Pinette and Rowe 1987	May Mountain	WP	Several criteria; white pine (40%)-red spruce (40%)-red pine
24	Pinette and Rowe 1987	Snowshoe Pond	WP	No major disturbance; white pine (29%) over red spruce (62%)
24	Pinette and Rowe 1987	Squa Pau Lake	WP	Selective harvest <50 yr; white pine (50%)-white-cedar (22%)-aspen-birch-spruce
25	Quinby 1988a	Temagami--Wakimika Triangle Area	WP-RP-JP	Old growth >140 yr
25	Quinby 1988a	Temagami--Red Pine	RP	Old growth >140 yr; red pine (77%)
25	Quinby 1988a	Temagami--White Pine-Black Spruce	WP	Old growth >140 yr; white pine (74%)-black spruce (11%)
25	Quinby 1988a	Temagami--White Pine-Cedar	WP	Old growth >140 yr; white pine (70%)-white-cedar (14%)
25	Quinby 1988a	Temagami--White Pine-Jack Pine	WP-JP	Old growth >140 yr; white pine (44%)-jack pine (30%)
25	Quinby 1988a	Temagami--White Pine-Populus	WP	Old growth >140 yr; white pine (81%)-poplar (7%)
25	Quinby 1988a	Temagami--White Pine-Red Pine	WP-RP	Old growth >140 yr; white pine (53%)-red pine (29%)
25	Quinby 1988a	Temagami--White Pine-White Birch	WP	Old growth >140 yr; white pine (62%)-white birch (18%)
26	Quinby 1988b	Algonquin Park--Jack Pine Type	JP-RP-WP	Mature stands (2), no recent disturbance; jack pine (70%)-red pine (9%)-white pine (5%)
26	Quinby 1988b	Algonquin Park--Red Pine Type	RP-WP-JP	Mature stands (5), no recent disturbance; red pine (64%)-white pine (16%)-jack pine (3%)
26	Quinby 1988b	Algonquin Park--White Pine Type	WP-RP	Mature stands (19), no recent disturbance; white pine (62%)-red pine (5%)
27	Quinby 1991	Temagami--Wakimika Triangle Area	WP-RP-JP	Old growth >140 yr; white pine (59%)-red pine (11%)
28	Robertson and Tiedje 1984	Hartwick Pines	WP-RP	No cutting since early 1800's; white pine-red pine-hemlock-hardwoods
29	Roman 1980	Five Ponds Wilderness-Upland Conifer	WP	Considered virgin in 1896; uncut; upland conifer white pine (68%)-red maple (21%)
29	Roman 1980	Five Ponds Wilderness--Plot 5	WP	Considered virgin in 1896; uncut; upland conifer white pine (68%)-red maple (21%)
29	Roman 1980	Five Ponds Wilderness--Plot 17	WP	Considered virgin in 1896; uncut; upland conifer white pine (68%)-red maple (21%)
29	Roman 1980	Five Ponds Wilderness--Plot 52	WP	Cpnsidered virgin in 1896; uncut; upland conifer white pine (81%)-red maple (10%)
29	Roman 1980	Five Ponds Wilderness--Plot 64	WP	Considered virgin in 1896; uncut; upland conifer white pine (68%)-red maple (21%)
30	Rose 1984	Hartwick Pines	WP-RP	Virgin; white pine (67%)
31	Shirley 1932	Cass Lake/Pike Bay	RP	Trees >200 yr; dead and dying trees removed at 5-yr intervals; red pine
32	Stai and Mladenoff 1993	August Lake	RP	Old-growth red pine > 175 yr
32	Stai and Mladenoff 1993	Bohall Lake	RP	Old-growth red pine > 175 yr
32	Stai and Mladenoff 1993	Burns Lake	RP	Old-growth red pine > 175 yr
32	Stai and Mladenoff 1993	Coon Lake 20	RP	Old-growth red pine > 175 yr
32	Stai and Mladenoff 1993	Hegman Lake	RP	Old-growth red pine > 175 yr
32	Stai and Mladenoff 1993	Loon Lake	WP	Old-growth white pine > 155 yr
32	Stai and Mladenoff 1993	Lost 40	RP	Old-growth red pine > 175 yr

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Map Key	Source/Date	Stand	Species of Pine	Criteria for Stand Selection and Stand Composition
32	Stai and Mladenoff 1993	Nicollet Trail	WP	Old-growth white pine > 155 yr
32	Stai and Mladenoff 1993	Onigum	WP	Old-growth white pine > 155 yr
32	Stai and Mladenoff 1993	Pine Point	RP	Old-growth red pine > 175 yr
32	Stai and Mladenoff 1993	Sandwick Lake	WP	Old-growth white pine > 155 yr
32	Stai and Mladenoff 1993	Sewage Pond	RP	Old-growth red pine > 175 yr
32	Stai and Mladenoff 1993	Snail Lake	WP	Old-growth white pine > 155 yr
32	Stai and Mladenoff 1993	Trout Lake	RP	Old-growth red pine > 175 yr
32	Stai and Mladenoff 1993	Twomey Williams Road	WP	Old-growth white pine > 155 yr
32	Stai and Mladenoff 1993	Voyageur Island	RP	Old-growth red pine > 175 yr
33	Stearns 1950	Gillen Refuge/Plum Lake	WP	Completely undisturbed; white pine

[1] Composition percentage based on basal area.

[2] Red pine <5%.

[3] Data are also included in conifer-northern hardwood forest type.

[4] Composition percentage of pine based on basal area.

[5] Composition based on overstory density.

[6] Criteria for considering stands as old growth: >0.4 ha, natural origin, ≥100 yr.

[7] Natural red pine stands >100 yr; minimal human disturbance.

[8] Age of trees unknown, but Thoreau visited in 1868 and described as jack pine stand (The Maine Woods).

[9] Stands of jack pine known for Schoodic Peninsula since 1880's.

[10] Largest pure red pine stand in Maine.

[11] Trees/stand called both old growth and second growth due to "relatively young age".

[12] Selection cut estimated 80 yr ago.

[13] Heterogeneous area, with jack pine forest.

[14] Trees/stand called both old growth and second growth.

[15] Red oak is 11% of seedling layer.

[16] Balsam fir is 37% of sapling layer.

[17] Stands differed in pine composition; on average white pine 9%, red pine 6%; some pine species sometimes absent.

[18] Some stands contained survivors from previous stand.

Table 69.—*Methods used to study old-growth northern pines (condensed from the cited references).*

Map Key	Source/Date	Stand	Sampling Methods
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 1	4 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 2	20 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 3	19 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 4	56 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 5	49 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 6	11 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 7	29 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 8	13 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 1	5 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 2	62 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 3	29 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 4	13 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 1	6 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 2	22 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 3	29 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 4	9 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 5	5 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 6	9 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 7	16 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 2	13 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 3	34 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 8	5 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 1	14 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 2	19 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 3	17 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 4	10 20 m x 20 m plots, randomly locatedat sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 5	2 20 m x 20 m plots, randomly located at sites ~200 m apart
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 6	8 20 m x 20 m plots, randomly located at sites ~200 m apart
2	Baldwin 1951	Bradford	1 0.1-ha plot
3	Bergman 1924	Areas in Northern Minnesota	9 100-m^2 quadrats; stump counts
4	Bourdo 1961	Baraga Co.	12 0.1-ha plots
5	Collins 1958	East Crawford Co.	100% cruise of southernmost tract
5	Collins 1958	East Roscommon	Cruise along strip 40 m wide
5	Collins 1958	Hartwick Pines	Cruise along strip 24 m wide
5	Collins 1958	Higgins Lake	100% cruise
5	Collins 1958	Houghton Lake	100% cruise
5	Collins 1958	Interlochen	Cruise along 2 strips 40 m wide

(Table 69 continued on next page)

(Table 69 continued)

Map Key	Source/Date	Stand	Sampling Methods
5	Collins 1958	Lake County	100% cruise
5	Collins 1958	Ogemaw County	100% cruise
5	Collins 1958	Presque Isle	100% cruise
5	Collins 1958	South Grayling	100% tally of red pine
6	Conkling 1978	Corrina	Sample plots using 10-factor prism; tree cores
6	Conkling 1978	Eagle Lake	Sample plots using 10-factor prism
6	Conkling 1978	Falmouth Interchange	Sample plots using 10-factor prism; tree cores
6	Conkling 1978	Mullen Woods	Direct count of all trees; tree cores
6	Conkling 1978	Pennesseewassee Lake--Stand I	Sample plots using 10-factor prism; tree cores
6	Conkling 1978	Pennesseewassee Lake--Stand II	Sample plots using 10-factor prism; tree cores
6	Conkling 1978	Presumpscot River	Sample plots using 10-factor prism; tree cores
6	Conkling 1978	Salsbury Cove	Sample plots using 10-factor prism; tree cores
7	Duvall 1997	Finnerud (108/109)	6 2.295-factor prism plots; 3 10-m transects per plot; tree cores
7	Duvall 1997	Hoist Lakes--C-97, St-40 (85)	5 2.295-factor prism plots; 3 10-m transects per plot; tree cores
7	Duvall 1997	Holloway Road--C-101, St-4 (83)	6 2.295-factor prism plots; 3 10-m transects per plot; tree cores
7	Duvall 1997	Indian River--C-18, St-26 (119)	6 2.295-factor prism plots; 3 10-m transects per plot; tree cores
7	Duvall 1997	Lost 40--Oldest Stand (112)	6 2.295-factor prism plots; 3 10-m transects per plot; tree cores
7	Duvall 1997	Lost 40--Younger Stand (121)	6 2.295-factor prism plots; 3 10-m transects per plot; tree cores
7	Duvall 1997	Nordhouse Dunes (123)	6 2.295-factor prism plots; 3 10-m transects per plot; tree cores
7	Duvall 1997	Squaw Creek--C-24, St-29 (110)	6 2.295-factor prism plots; 3 10-m transects per plot; tree cores
7	Duvall 1997	Squirrel River (106)	6 2.295-factor prism plots; 3 10-m transects per plot; tree cores
7	Duvall 1997	Tomahawk River (107)	2 2.295-factor prism plots; 3 10-m transects per plot; tree cores
7	Duvall 1997	Valley Road--C-123, St-31 (82)	6 2.295-factor prism plots; 3 10-m transects per plot; tree cores
7	Duvall 1997	Westlake--C-87, St-11 (111)	3 2.295-factor prism plots; 3 10-m transects per plot; tree cores
7	Duvall 1997	Wilber--C-100, St-13 (84)	6 2.295-factor prism plots; 3 10-m transects per plot; tree cores
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--1	Unspecified
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--2	Unspecified
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--3	Unspecified
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--1	Unspecified
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--2	Unspecified
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--3	Unspecified
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--1	Unspecified
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--2	Unspecified
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--3	Unspecified
9	Graves 1899	Round Pond Township 23	Unspecified
10	Heinselman 1973	Amoeber Lake--Plot 11	Circular plots 0.08 to 0.008 ha in size
10	Heinselman 1973	Cash Lake--Plot 32	Circular plots 0.08 to 0.008 ha in size

(Table 69 continued on next page)

(Table 69 continued)

Map Key	Source/Date	Stand	Sampling Methods
10	Heinselman 1973	Echo Trail--Plot 29	Circular plots 0.08 to 0.008 ha in size
10	Heinselman 1973	Ester Lake--Plot 15	Circular plots 0.08 to 0.008 ha in size
10	Heinselman 1973	Insula Lake--Plot 25	Circular plots 0.08 to 0.008 ha in size
10	Heinselman 1973	Keeley Creek--Plot 27	Circular plots 0.08 to 0.008 ha in size
10	Heinselman 1973	Moose River, S.--Plot 3	Circular plots 0.08 to 0.008 ha in size
10	Heinselman 1973	North Hegman Lake--Plot 28	Circular plots 0.08 to 0.008 ha in size
10	Heinselman 1973	Seagull Lake--Plot 6	Circular plots 0.08 to 0.008 ha in size
10	Heinselman 1973	Seagull Lake--Plot 7	Circular plots 0.08 to 0.008 ha in size
10	Heinselman 1973	Stand A-5, Gaskin Lake	Unspecified
10	Heinselman 1973	Stand A-8, Boulder Bay, Lac La Croix	Unspecified
11	Holla and Knowles 1988	Sandford Lake	Point-centered quarter every 30m along parallel transects
12	Hough and Forbes 1943	Cook Forest	Cites earlier studies
12	Hough and Forbes 1943	East Tionesta Forest--Plot 8	1 0.4-ha plot
12	Hough and Forbes 1943	East Tionesta Forest--Plot 9	1 0.4-ha plot
13	Iles 1990	Core 1/Tikamaganda Lake--White Pine	Database search and air photo interpretation
13	Iles 1990	Core 2/Galloway Lake--White Pine	Database search and air photo interpretation
13	Iles 1990	Core 3/Bliss Lake--White Pine	Database search and air photo interpretation
13	Iles 1990	Core 4/Quinn Lake--White Pine	Database search and air photo interpretation
13	Iles 1990	Core 5/Bark Lake--Jack Pine	Database search and air photo interpretation
13	Iles 1990	Core 5/Bark Lake--Red Pine	Database search and air photo interpretation
13	Iles 1990	Core 5/Bark Lake--White Pine	Database search and air photo interpretation
13	Iles 1990	Core 6/Dave Lake--Jack Pine	Database search and air photo interpretation
13	Iles 1990	Core 6/Dave Lake--Red Pine	Database search and air photo interpretation
13	Iles 1990	Core 6/Dave Lake--White Pine	Database search and air photo interpretation
13	Iles 1990	Core 7/Rushbrook Lake--Jack Pine	Database search and air photo interpretation
13	Iles 1990	Core 7/Rushbrook Lake--White Pine	Database search and air photo interpretation
13	Iles 1990	Core 8/Wolf Lake--Jack Pine	Database search and air photo interpretation
13	Iles 1990	Core 8/Wolf Lake--Red Pine	Database search and air photo interpretation
13	Iles 1990	Core 9/Obabika Lake--Red Pine	Database search and air photo interpretation
13	Iles 1990	Core 9/Obabika Lake--White Pine	Database search and air photo interpretation
13	Iles 1990	Core 10/Kokoko Bay--Red Pine	Database search and air photo interpretation
13	Iles 1990	Core 10/Kokoko Bay--White Pine	Database search and air photo interpretation
14	Kittredge 1934	Star Island--East Transitional Stand	6 0.08- or 0.1-ha plots
14	Kittredge 1934	Star Island--NW Windigo Jack Pine	6 0.1-ha plots
14	Kittredge 1934	Star Island--NW Windigo Norway Pine	6 0.08- or 0.1-ha plots
14	Kittredge 1934	Star Island--White Pine	6 0.08- or 0.1-ha plots
15	Kittredge and Chittenden 1929	Interlochen State Park	Stem analysis on 0.08-ha plot

(Table 69 continued on next page)

(Table 69 continued)

Map Key	Source/Date	Stand	Sampling Methods
16	Lutz and McComb 1935	Ludlow	Stem and branch growth measurements
17	Maine Critical Areas Program 1983a	Attean Pond	Completing data form, increment cores
17	Maine Critical Areas Program 1983a	Big Island - Lobster Lake	Completing data form, increment cores
17	Maine Critical Areas Program 1983a	Bradstreet Jack Pine Natural Area	Completing data form, increment cores
17	Maine Critical Areas Program 1983a	Cadillac Mountain	Completing data form, increment cores
17	Maine Critical Areas Program 1983a	Dyer Neck	Completing data form, increment cores
17	Maine Critical Areas Program 1983a	First Debsconeag Lake	Completing data form, increment cores
17	Maine Critical Areas Program 1983a	Great Wass Island	Completing data form, increment cores
17	Maine Critical Areas Program 1983a	Holeb Pond	Completing data form, increment cores
17	Maine Critical Areas Program 1983a	Louse Island - Matagamon Lake	Completing data form
17	Maine Critical Areas Program 1983a	North of Schoodic Trail	Completing data form, increment cores
17	Maine Critical Areas Program 1983a	Passamagamet	Completing data form, increment cores
17	Maine Critical Areas Program 1983a	Schoodic Peninsula	Completing data form, increment cores
17	Maine Critical Areas Program 1983a	Umbagog Lake	Completing data form, increment cores
17	Maine Critical Areas Program 1983a	Wonsqueak	Completing data form, increment cores
18	Maine Critical Areas Program 1983b	Baker Pond	Completing data form, increment cores
18	Maine Critical Areas Program 1983b	Bald Mountain	Completing data form, increment cores
18	Maine Critical Areas Program 1983b	Big Island - Lobster Lake	Completing data form, increment cores
18	Maine Critical Areas Program 1983b	Cathedral Pines	Completing data form, increment cores
18	Maine Critical Areas Program 1983b	Chesuncook Lake	Completing data form, increment cores
18	Maine Critical Areas Program 1983b	Cliff Ridge	Completing data form, increment cores
18	Maine Critical Areas Program 1983b	Debsconeag Lake	Completing data form, increment cores
18	Maine Critical Areas Program 1983b	Gero Island	Completing data form, increment cores
18	Maine Critical Areas Program 1983b	Hollis	Completing data form, increment cores
18	Maine Critical Areas Program 1983b	Huston Brook	Completing data form, increment cores
18	Maine Critical Areas Program 1983b	Moosehorn Stream	Completing data form, increment cores
18	Maine Critical Areas Program 1983b	Newcastle	Completing data form, increment cores
18	Maine Critical Areas Program 1983b	No. 5 Bog	Completing data form, increment cores
18	Maine Critical Areas Program 1983b	Pine Stream Flowage	Completing data form, increment cores
18	Maine Critical Areas Program 1983b	Spencer Lake	Completing data form, increment cores
18	Maine Critical Areas Program 1983b	The Pines	Completing data form, increment cores
18	Maine Critical Areas Program 1983b	Wassataquoik Stream	Completing data form, increment cores
19	Methven 1973	Chalk River - Petewawa	Tally in 0.41-ha plot
20	Milfred et al. 1967	Stand 04	5 circular 0.04-ha plots
20	Milfred et al. 1967	Stand 10	5 circular 0.04-ha plots
20	Milfred et al. 1967	Stand 35	5 circular 0.04-ha plots
21	Morey 1936b	Hearts Content	Measured 200 trees measured before cutting; stump ages

(Table 69 continued on next page)

(Table 69 continued)

Map Key	Source/Date	Stand	Sampling Methods
22	Ohmann and Ream 1971b	Jack Pine (Oak)--11 Stands	20 point-center quarters in each stand; stands randomly selected [1]
22	Ohmann and Ream 1971b	Jack Pine (Fir)--7 Stands	20 point-center quarters in each stand; stands randomly selected [1]
22	Ohmann and Ream 1971b	Mixed Pine-Black Spruce--7 Stands	20 point-center quarters in each stand; stands randomly selected [1]
22	Ohmann and Ream 1971b	Red Pine--4 Stands	20 point-center quarters in each stand; stands randomly selected [1]
22	Ohmann and Ream 1971b	White Pine--6 Stands	20 point-center quarters in each stand; stands randomly selected [1]
23	Peet 1984	Lake Itasca--1957	1 0.48-ha permanent plot, originally measured by Sudia
23	Peet 1984	Lake Itasca--1983	1 0.48-ha permanent plot, remeasured
24	Pinette and Rowe 1987	May Mountain	8 prism plots
24	Pinette and Rowe 1987	Snowshoe Pond	1 prism plot
24	Pinette and Rowe 1987	Squa Pau Lake	3 prism plots
25	Quinby 1988a	Temagami--Wakimika Triangle Area	40 20 m x 50 m plots; placed to include 2 pine >60cm d.b.h. [2]
25	Quinby 1988a	Temagami--Red Pine	4 20 m x 50 m plots; placed to maximize trees >60cm d.b.h. [2]
25	Quinby 1988a	Temagami--White Pine-Black Spruce	5 20 m x 50 m plots; placed to maximize trees >60cm d.b.h. [2]
25	Quinby 1988a	Temagami--White Pine-Cedar	3 20 m x 50 m plots; placed to maximize trees >60cm d.b.h. [2]
25	Quinby 1988a	Temagami--White Pine-Jack Pine	1 20 m x 50 m plot; placed to maximize trees >60cm d.b.h. [2]
25	Quinby 1988a	Temagami--White Pine-Populus	1 20 m x 50 m plot; placed to maximize trees >60cm d.b.h. [2]
25	Quinby 1988a	Temagami--White Pine-Red Pine	10 20 m x 50 m plots; placed to maximize trees >60cm d.b.h. [2]
25	Quinby 1988a	Temagami--White Pine-White Birch	16 20 m x 50 m plots; placed to maximize trees >60cm d.b.h. [2]
26	Quinby 1988b	Algonquin Park--Jack Pine Type	3 randomly placed 10 m x 30 m quadrats within each stand
26	Quinby 1988b	Algonquin Park--Red Pine Type	3 randomly placed 10 m x 30 m quadrats within each stand
26	Quinby 1988b	Algonquin Park--White Pine Type	3 randomly placed 10 m x 30 m quadrats within each stand
27	Quinby 1991	Temagami--Wakimika Triangle Area	38 20 m x 50 m plots; placed to include 2 trees >60 cm d.b.h. [2]
28	Robertson and Tiedje 1984	Hartwick Pines	soil samples, tree age estimates
29	Roman 1980	Five Ponds Wilderness-Upland Conifer	1 50 m x 20 m plot per stand
29	Roman 1980	Five Ponds Wilderness--Plot 5	1 50 m x 20 m plot
29	Roman 1980	Five Ponds Wilderness--Plot 17	1 50 m x 20 m plot
29	Roman 1980	Five Ponds Wilderness--Plot 52	1 50 m x 20 m plot
29	Roman 1980	Five Ponds Wilderness--Plot 64	1 50 m x 20 m plot
30	Rose 1984	Hartwick Pines	20 randomly selected 200-m2 circular plots
31	Shirley 1932	Cass Lake/Pike Bay	50 plots, each with 2 0.0004-ha quadrats for age and height
32	Stai and Mladenoff 1993	August Lake	1 20 m x 50 m plot; 5 trees cored
32	Stai and Mladenoff 1993	Bohall Lake	1 20 m x 50 m plot; 5 trees cored
32	Stai and Mladenoff 1993	Burns Lake	1 20 m x 50 m plot; 5 trees cored
32	Stai and Mladenoff 1993	Coon Lake 20	1 20 m x 50 m plot; 5 trees cored
32	Stai and Mladenoff 1993	Hegman Lake	1 20 m x 50 m plot; 5 trees cored
32	Stai and Mladenoff 1993	Loon Lake	1 20 m x 50 m plot; 5 trees cored
32	Stai and Mladenoff 1993	Lost 40	1 20 m x 50 m plot; 5 trees cored

(Table 69 continued on next page)

(Table 69 continued)

Map Key	Source/Date	Stand	Sampling Methods
32	Stai and Mladenoff 1993	Nicollet Trail	1 20 m x 50 m plot; 5 trees cored
32	Stai and Mladenoff 1993	Onigum	1 20 m x 50 m plot; 5 trees cored
32	Stai and Mladenoff 1993	Pine Point	1 20 m x 50 m plot; 5 trees cored
32	Stai and Mladenoff 1993	Sandwick Lake	1 20 m x 50 m plot; 5 trees cored
32	Stai and Mladenoff 1993	Sewage Pond	1 20 m x 50 m plot; 5 trees cored
32	Stai and Mladenoff 1993	Snail Lake	1 20 m x 50 m plot; 5 trees cored
32	Stai and Mladenoff 1993	Trout Lake	1 20 m x 50 m plot; 5 trees cored
32	Stai and Mladenoff 1993	Twomey Williams Road	1 20 m x 50 m plot; 5 trees cored
32	Stai and Mladenoff 1993	Voyageur Island	1 20 m x 50 m plot; 5 trees cored
33	Stearns 1950	Gillen Refuge/Plum Lake	4 100-m^2 quadrats

[1] For methods, see Ohmann and Ream (1971a).

[2] Plots were located to include 2 pines ≥60 cm and ≥140 yr.

Table 70.—*Density of live trees ≥10, ≥50, and ≥70 cm for northern pine old-growth study sites. For other minimum sizes, the density is listed under "≥X cm", with the minimum size for tallying trees given as "Min Diam X (cm)".*

			Live Tree Density				
Map Key	Source/Date	Stand	≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X cm (#/ha)	Min Diam X (cm)
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 1	388 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 2	204 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 3	288 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 4	280 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 5	646 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 6	628 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 7	404 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 8	653 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 1	1479 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 2	694 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 3	514 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 4	812 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 1	534 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 2	938 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 3	533 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 4	426 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 5	470 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 6	412 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 7	151 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 2	282 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 3	689 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 8	495 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 1	269 [2,3]				
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 2	417 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 3	472 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 4	320 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 5	250 [1]				
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 6	378 [1]				
2	Baldwin 1951	Bradford				889	5
3	Bergman 1924	Areas in Northern Minnesota				800-1200 [4]	all trees
4	Bourdo 1961	Baraga County				1457 [5]	2.5
5	Collins 1958	East Crawford County				89 [6]	25.4
5	Collins 1958	East Roscommon				104 [6]	25.4
5	Collins 1958	Hartwick Pines				31 [6]	25.4
5	Collins 1958	Higgins Lake				106 [6]	25.4
5	Collins 1958	Houghton Lake				47 [6]	25.4
5	Collins 1958	Interlochen				16 [6]	25.4

(Table 70 continued on next page)

(Table 70 continued)

Map Key	Source/Date	Stand	Live Tree Density ≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X cm (#/ha)	Min Diam X (cm)
5	Collins 1958	Lake County				63[6]	25.4
5	Collins 1958	Ogemaw County				77[6]	25.4
5	Collins 1958	Presque Isle				64[6]	25.4
5	Collins 1958	South Grayling				10[6]	25.4
6	Conkling 1978	Corrina					
6	Conkling 1978	Eagle Lake					
6	Conkling 1978	Falmouth Interchange					
6	Conkling 1978	Mullen Woods					
6	Conkling 1978	Pennesseewassee Lake--Stand I					
6	Conkling 1978	Pennesseewassee Lake--Stand II					
6	Conkling 1978	Presumpscot River					
6	Conkling 1978	Salsbury Cove					
7	Duvall 1997	Finnerud (108/109)					
7	Duvall 1997	Hoist Lakes--C-97, St-40 (85)					
7	Duvall 1997	Holloway Road--C-101, St-4 (83)					
7	Duvall 1997	Indian River--C-18, St-26 (119)					
7	Duvall 1997	Lost 40--Oldest Stand (112)					
7	Duvall 1997	Lost 40--Younger Stand (121)					
7	Duvall 1997	Nordhouse Dunes (123)					
7	Duvall 1997	Squaw Creek--C-24, St-29 (110)					
7	Duvall 1997	Squirrel River (106)					
7	Duvall 1997	Tomahawk River (107)					
7	Duvall 1997	Valley Road--C-123, St-31 (82)					
7	Duvall 1997	Westlake--C-87, St-11 (111)					
7	Duvall 1997	Wilber--C-100, St-13 (84)					
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--1				692	12.7
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--2				647	12.7
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--3				642	12.7
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--1				494	12.7
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--2				459	12.7
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--3				445	12.7
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--1				380	12.7
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--2				496	12.7
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--3				333	12.7
9	Graves 1899	Round Pond Township 23					
10	Heinselman 1973	Amoeber Lake--Plot 11				1729	2.54
10	Heinselman 1973	Cash Lake--Plot 32				1643	2.54

(Table 70 continued on next page)

(Table 70 continued)

Map Key	Source/Date	Stand	Live Tree Density				Min Diam X (cm)
			≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X cm (#/ha)	
10	Heinselman 1973	Echo Trail--Plot 29				1618	2.54
10	Heinselman 1973	Ester Lake--Plot 15				1754	2.54
10	Heinselman 1973	Insula Lake--Plot 25				1013	2.54
10	Heinselman 1973	Keeley Creek--Plot 27				877	2.54
10	Heinselman 1973	Moose River, S.--Plot 3				1161	2.54
10	Heinselman 1973	North Hegman Lake--Plot 28				1778	2.54
10	Heinselman 1973	Seagull Lake--Plot 6				2569	2.54
10	Heinselman 1973	Seagull Lake--Plot 7				2137	2.54
10	Heinselman 1973	Stand A-5, Gaskin Lake				1828	2.54
10	Heinselman 1973	Stand A-8, Boulder Bay, Lac La Croix				1988	2.54
11	Holla and Knowles 1988	Sandford Lake					
12	Hough and Forbes 1943	Cook Forest					
12	Hough and Forbes 1943	East Tionesta Forest--Plot 8					
12	Hough and Forbes 1943	East Tionesta Forest--Plot 9					
13	Iles 1990	Core 1/Tikamaganda Lake--White Pine					
13	Iles 1990	Core 2/Galloway Lake--White Pine					
13	Iles 1990	Core 3/Bliss Lake--White Pine					
13	Iles 1990	Core 4/Quinn Lake--White Pine					
13	Iles 1990	Core 5/Bark Lake--Jack Pine					
13	Iles 1990	Core 5/Bark Lake--Red Pine					
13	Iles 1990	Core 5/Bark Lake--White Pine					
13	Iles 1990	Core 6/Dave Lake--Jack Pine					
13	Iles 1990	Core 6/Dave Lake--Red Pine					
13	Iles 1990	Core 6/Dave Lake--White Pine					
13	Iles 1990	Core 7/Rushbrook Lake--Jack Pine					
13	Iles 1990	Core 7/Rushbrook Lake--White Pine					
13	Iles 1990	Core 8/Wolf Lake--Jack Pine					
13	Iles 1990	Core 8/Wolf Lake--Red Pine					
13	Iles 1990	Core 9/Obabika Lake--Red Pine					
13	Iles 1990	Core 9/Obabika Lake--White Pine					
13	Iles 1990	Core 10/Kokoko Bay--Red Pine					
13	Iles 1990	Core 10/Kokoko Bay--White Pine					
14	Kittredge 1934	Star Island--East Transitional Stand		188	59	257	25
14	Kittredge 1934	Star Island--NW Windigo Jack Pine		0	0	454	25
14	Kittredge 1934	Star Island--NW Windigo Norway Pine		99	0	494	25
14	Kittredge 1934	Star Island--White Pine	198	49	0	59	25
15	Kittredge and Chittenden 1929	Interlochen State Park	309	86	0	124	25

(Table 70 continued on next page)

(Table 70 continued)

Map Key	Source/Date	Stand	Live Tree Density				
			≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X cm (#/ha)	Min Diam X (cm)
16	Lutz and McComb 1935	Ludlow				49 [7]	unspecified
17	Maine Critical Areas Program 1983a	Attean Pond					
17	Maine Critical Areas Program 1983a	Big Island - Lobster Lake					
17	Maine Critical Areas Program 1983a	Bradstreet Jack Pine Natural Area					
17	Maine Critical Areas Program 1983a	Cadillac Mountain					
17	Maine Critical Areas Program 1983a	Dyer Neck					
17	Maine Critical Areas Program 1983a	First Debsconeag Lake					
17	Maine Critical Areas Program 1983a	Great Wass Island					
17	Maine Critical Areas Program 1983a	Holeb Pond					
17	Maine Critical Areas Program 1983a	Louse Island - Matagamon Lake					
17	Maine Critical Areas Program 1983a	North of Schoodic Trail					
17	Maine Critical Areas Program 1983a	Passamagamet					
17	Maine Critical Areas Program 1983a	Schoodic Peninsula					
17	Maine Critical Areas Program 1983a	Umbagog Lake					
17	Maine Critical Areas Program 1983a	Wonsqueak					
18	Maine Critical Areas Program 1983b	Baker Pond					
18	Maine Critical Areas Program 1983b	Bald Mountain					
18	Maine Critical Areas Program 1983b	Big Island - Lobster Lake					
18	Maine Critical Areas Program 1983b	Cathedral Pines					
18	Maine Critical Areas Program 1983b	Chesuncook Lake					
18	Maine Critical Areas Program 1983b	Cliff Ridge					
18	Maine Critical Areas Program 1983b	Debsconeag Lake					
18	Maine Critical Areas Program 1983b	Gero Island					
18	Maine Critical Areas Program 1983b	Hollis					
18	Maine Critical Areas Program 1983b	Huston Brook					
18	Maine Critical Areas Program 1983b	Moosehorn Stream					
18	Maine Critical Areas Program 1983b	Newcastle					
18	Maine Critical Areas Program 1983b	No. 5 Bog					
18	Maine Critical Areas Program 1983b	Pine Stream Flowage					
18	Maine Critical Areas Program 1983b	Spencer Lake					
18	Maine Critical Areas Program 1983b	The Pines					
18	Maine Critical Areas Program 1983b	Wassataquoik Stream					
19	Methven 1973	Chalk River - Petewawa				840	>5 m tall
20	Milfred et al. 1967	Stand 04		97 [8]	44 [9]	395	8.9
20	Milfred et al. 1967	Stand 10		109 [8]	14.8 [9]	934	8.9
20	Milfred et al. 1967	Stand 35		44 [8]	10 [9]	588	8.9
21	Morey 1936b	Hearts Content					

(Table 70 continued on next page)

(Table 70 continued)

Map Key	Source/Date	Stand	Live Tree Density ≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X cm (#/ha)	Min Diam X (cm)
22	Ohmann and Ream 1971b	Jack Pine (Oak)--11 Stands	776 [10]				
22	Ohmann and Ream 1971b	Jack Pine (Fir)--7 Stands	988 [11]				
22	Ohmann and Ream 1971b	Mixed Pine-Black Spruce--7 Stands	709 [10]				
22	Ohmann and Ream 1971b	Red Pine--4 Stands	610 [12]				
22	Ohmann and Ream 1971b	White Pine--6 Stands	748 [12]				
23	Peet 1984	Lake Itasca--1957				606	2.5
23	Peet 1984	Lake Itasca--1983				541	2.5
24	Pinette and Rowe 1987	May Mountain					
24	Pinette and Rowe 1987	Snowshoe Pond					
24	Pinette and Rowe 1987	Squa Pau Lake					
25	Quinby 1988a	Temagami--Wakimika Triangle Area					
25	Quinby 1988a	Temagami--Red Pine				5 [13]	60
25	Quinby 1988a	Temagami--White Pine-Black Spruce				22 [13]	60
25	Quinby 1988a	Temagami--White Pine-Cedar				53 [13]	60
25	Quinby 1988a	Temagami--White Pine-Jack Pine				0 [13]	60
25	Quinby 1988a	Temagami--White Pine-Populus				30 [13]	60
25	Quinby 1988a	Temagami--White Pine-Red Pine				21 [13]	60
25	Quinby 1988a	Temagami--White Pine-White Birch				29 [13]	60
26	Quinby 1988b	Algonquin Park--Jack Pine Type					2
26	Quinby 1988b	Algonquin Park--Red Pine Type					
26	Quinby 1988b	Algonquin Park--White Pine Type					
27	Quinby 1991	Temagami--Wakimika Triangle Area					
28	Robertson and Tiedje 1984	Hartwick Pines					
29	Roman 1980	Five Ponds Wilderness-Upland Conifer	418 [14]				
29	Roman 1980	Five Ponds Wilderness--Plot 5	360				
29	Roman 1980	Five Ponds Wilderness--Plot 17	360				
29	Roman 1980	Five Ponds Wilderness--Plot 52	410				
29	Roman 1980	Five Ponds Wilderness--Plot 64	540				
30	Rose 1984	Hartwick Pines				630	>1.4 m tall
31	Shirley 1932	Cass Lake/Pike Bay					
32	Stai and Mladenoff 1993	August Lake	650	40	0		
32	Stai and Mladenoff 1993	Bohall Lake	480	40	0		
32	Stai and Mladenoff 1993	Burns Lake	590	130	30		
32	Stai and Mladenoff 1993	Coon Lake 20	430	140	40		
32	Stai and Mladenoff 1993	Hegman Lake	300	90	0		
32	Stai and Mladenoff 1993	Loon Lake	530	120	50		
32	Stai and Mladenoff 1993	Lost 40	310	100	50		

(Table 70 continued on next page)

(Table 70 continued)

Map Key	Source/Date	Stand	Live Tree Density ≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X cm (#/ha)	Min Diam X (cm)
32	Stai and Mladenoff 1993	Nicollet Trail	290	140	10		
32	Stai and Mladenoff 1993	Onigum	490	100	50		
32	Stai and Mladenoff 1993	Pine Point	460	70	30		
32	Stai and Mladenoff 1993	Sandwick Lake	300	110	90		
32	Stai and Mladenoff 1993	Sewage Pond	290	90	10		
32	Stai and Mladenoff 1993	Snail Lake	310	140	10		
32	Stai and Mladenoff 1993	Trout Lake	470	110	0		
32	Stai and Mladenoff 1993	Twomey Williams Road	470	140	80		
32	Stai and Mladenoff 1993	Voyageur Island	360	70	0		
33	Stearns 1950	Gillen Refuge/Plum Lake	1450			300	30.5

[1] Density of trees is computed from density of red or white pine and from the relative density of the pine.

[2] Stand density computed from density for white pine and relative density of white pine.

[3] Discrepancy exists when computing density of trees from relative density of white pine and from red pine (292 vs 269).

[4] Density of white pine = 256/ha; of red pine = 333/ha.

[5] Density of red pine = 42/ha, of white pine 125/ha.

[6] Density figures for red pine only (>80% of stand density).

[7] Density for white pine only.

[8] These values are densities ≥50.8 cm (not ≥50).

[9] These values are densities ≥69.85 cm (not ≥70).

[10] Density for jack pine and black spruce only.

[11] Density for jack pine, balsam fir, and black spruce only.

[12] Density for red and white pine only.

[13] Plots oriented to include big trees, so density may be affected.

[14] Average for 4 upland conifer stands.

Table 71.—*Basal area of live trees ≥10, ≥50, and ≥70 cm for northern pine old-growth study sites. For other minimum sizes, the basal area is listed under "≥X cm", with the minimum size for tallying trees given as "Min Diam X (cm)".*

			Live Tree Basal Area (BA)				
Map Key	Source/Date	Stand	≥10 cm (m^2/ha)	≥50 cm (m^2/ha)	≥70 cm (m^2/ha)	≥X cm (m^2/ha)	Min Diam X (cm)
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 1					
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 2					
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 3					
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 4					
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 5					
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 6					
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 7					
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 8					
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 1					
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 2					
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 3					
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 4					
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 1					
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 2					
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 3					
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 4					
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 5					
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 6					
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 7					
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 2					
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 3					
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 8					
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 1					
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 2					
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 3					
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 4					
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 5					
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 6					
2	Baldwin 1951	Bradford				148.0	5
3	Bergman 1924	Areas in Northern Minnesota					
4	Bourdo 1961	Baraga County				44.3	5
5	Collins 1958	East Crawford County				16.5 [1]	25.4
5	Collins 1958	East Roscommon				16.0 [1]	25.4
5	Collins 1958	Hartwick Pines				5.0 [1]	25.4
5	Collins 1958	Higgins Lake				18.3 [1]	25.4
5	Collins 1958	Houghton Lake				7.8 [1]	25.4
5	Collins 1958	Interlochen				2.6 [1]	25.4

(Table 71 continued on next page)

(Table 71 continued)

Map Key	Source/Date	Stand	Live Tree Basal Area (BA)				
			≥10 cm (m^2/ha)	≥50 cm (m^2/ha)	≥70 cm (m^2/ha)	≥X cm (m^2/ha)	Min Diam X (cm)
5	Collins 1958	Lake County				9.1[1]	25.4
5	Collins 1958	Ogemaw County				11.1[1]	25.4
5	Collins 1958	Presque Isle				15.2[1]	25.4
5	Collins 1958	South Grayling				2.1[1]	25.4
6	Conkling 1978	Corrina					
6	Conkling 1978	Eagle Lake					
6	Conkling 1978	Falmouth Interchange					
6	Conkling 1978	Mullen Woods					
6	Conkling 1978	Pennesseewassee Lake--Stand I					
6	Conkling 1978	Pennesseewassee Lake--Stand II					
6	Conkling 1978	Presumpscot River					
6	Conkling 1978	Salsbury Cove					
7	Duvall 1997	Finnerud (108/109)				52.5	>1.4 m tall
7	Duvall 1997	Hoist Lakes--C-97, St-40 (85)				34.0	>1.4 m tall
7	Duvall 1997	Holloway Road--C-101, St-4 (83)				23.0	>1.4 m tall
7	Duvall 1997	Indian River--C-18, St-26 (119)				29.9	>1.4 m tall
7	Duvall 1997	Lost 40--Oldest Stand (112)				42.2	>1.4 m tall
7	Duvall 1997	Lost 40--Younger Stand (121)				38.0	>1.4 m tall
7	Duvall 1997	Nordhouse Dunes (123)				26.5	>1.4 m tall
7	Duvall 1997	Squaw Creek--C-24, St-29 (110)				33.7	>1.4 m tall
7	Duvall 1997	Squirrel River (106)				39.1	>1.4 m tall
7	Duvall 1997	Tomahawk River (107)				51.8	>1.4 m tall
7	Duvall 1997	Valley Road--C-123, St-31 (82)				34.1	>1.4 m tall
7	Duvall 1997	Westlake--C-87, St-11 (111)				29.9	>1.4 m tall
7	Duvall 1997	Wilber--C-100, St-13 (84)				46.8	>1.4 m tall
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--1				37.2	12.7
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--2				37.6	12.7
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--3				37.6	12.7
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--1				40.4	12.7
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--2				40.6	12.7
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--3				40.9	12.7
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--1				42.7	12.7
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--2				42.9	12.7
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--3				43.1	12.7
9	Graves 1899	Round Pond Township 23					
10	Heinselman 1973	Amoeber Lake--Plot 11				35.6	2.5
10	Heinselman 1973	Cash Lake--Plot 32				28.5	2.5

(Table 71 continued on next page)

(Table 71 continued)

Map Key	Source/Date	Stand	Live Tree Basal Area (BA)				
			≥10 cm (m^2/ha)	≥50 cm (m^2/ha)	≥70 cm (m^2/ha)	≥X cm (m^2/ha)	Min Diam X (cm)
10	Heinselman 1973	Echo Trail--Plot 29				23.4	2.5
10	Heinselman 1973	Ester Lake--Plot 15				30.1	2.5
10	Heinselman 1973	Insula Lake--Plot 25				35.1	2.5
10	Heinselman 1973	Keeley Creek--Plot 27				21.3	2.5
10	Heinselman 1973	Moose River, S.--Plot 3				24.6	2.5
10	Heinselman 1973	North Hegman Lake--Plot 28				22.9	2.5
10	Heinselman 1973	Seagull Lake--Plot 6				23.0	2.5
10	Heinselman 1973	Seagull Lake--Plot 7				20.0	2.5
10	Heinselman 1973	Stand A-5, Gaskin Lake				40.9	2.5
10	Heinselman 1973	Stand A-8, Boulder Bay, Lac La Croix				49.4	2.5
11	Holla and Knowles 1988	Sandford Lake					
12	Hough and Forbes 1943	Cook Forest					
12	Hough and Forbes 1943	East Tionesta Forest--Plot 8					
12	Hough and Forbes 1943	East Tionesta Forest--Plot 9					
13	Iles 1990	Core 1/Tikamaganda Lake--White Pine					
13	Iles 1990	Core 2/Galloway Lake--White Pine					
13	Iles 1990	Core 3/Bliss Lake--White Pine					
13	Iles 1990	Core 4/Quinn Lake--White Pine					
13	Iles 1990	Core 5/Bark Lake--Jack Pine					
13	Iles 1990	Core 5/Bark Lake--Red Pine					
13	Iles 1990	Core 5/Bark Lake--White Pine					
13	Iles 1990	Core 6/Dave Lake--Jack Pine					
13	Iles 1990	Core 6/Dave Lake--Red Pine					
13	Iles 1990	Core 6/Dave Lake--White Pine					
13	Iles 1990	Core 7/Rushbrook Lake--Jack Pine					
13	Iles 1990	Core 7/Rushbrook Lake--White Pine					
13	Iles 1990	Core 8/Wolf Lake--Jack Pine					
13	Iles 1990	Core 8/Wolf Lake--Red Pine					
13	Iles 1990	Core 9/Obabika Lake--Red Pine					
13	Iles 1990	Core 9/Obabika Lake--White Pine					
13	Iles 1990	Core 10/Kokoko Bay--Red Pine					
13	Iles 1990	Core 10/Kokoko Bay--White Pine					
14	Kittredge 1934	Star Island--East Transitional Stand					
14	Kittredge 1934	Star Island--NW Windigo Jack Pine					
14	Kittredge 1934	Star Island--NW Windigo Norway Pine					
14	Kittredge 1934	Star Island--White Pine					
15	Kittredge and Chittenden 1929	Interlochen State Park				25.4 [2]	27.9

(Table 71 continued on next page)

(Table 71 continued)

Map Key	Source/Date	Stand	Live Tree Basal Area (BA) ≥10 cm (m²/ha)	≥50 cm (m²/ha)	≥70 cm (m²/ha)	≥X cm (m²/ha)	Min Diam X (cm)
16	Lutz and McComb 1935	Ludlow					
17	Maine Critical Areas Program 1983a	Attean Pond					
17	Maine Critical Areas Program 1983a	Big Island - Lobster Lake					
17	Maine Critical Areas Program 1983a	Bradstreet Jack Pine Natural Area					
17	Maine Critical Areas Program 1983a	Cadillac Mountain					
17	Maine Critical Areas Program 1983a	Dyer Neck					
17	Maine Critical Areas Program 1983a	First Debsconeag Lake					
17	Maine Critical Areas Program 1983a	Great Wass Island					
17	Maine Critical Areas Program 1983a	Holeb Pond					
17	Maine Critical Areas Program 1983a	Louse Island - Matagamon Lake					
17	Maine Critical Areas Program 1983a	North of Schoodic Trail					
17	Maine Critical Areas Program 1983a	Passamagamet					
17	Maine Critical Areas Program 1983a	Schoodic Peninsula					
17	Maine Critical Areas Program 1983a	Umbagog Lake					
17	Maine Critical Areas Program 1983a	Wonsqueak					
18	Maine Critical Areas Program 1983b	Baker Pond					
18	Maine Critical Areas Program 1983b	Bald Mountain					
18	Maine Critical Areas Program 1983b	Big Island - Lobster Lake					
18	Maine Critical Areas Program 1983b	Cathedral Pines					
18	Maine Critical Areas Program 1983b	Chesuncook Lake					
18	Maine Critical Areas Program 1983b	Cliff Ridge					
18	Maine Critical Areas Program 1983b	Debsconeag Lake					
18	Maine Critical Areas Program 1983b	Gero Island					
18	Maine Critical Areas Program 1983b	Hollis					
18	Maine Critical Areas Program 1983b	Huston Brook					
18	Maine Critical Areas Program 1983b	Moosehorn Stream					
18	Maine Critical Areas Program 1983b	Newcastle					
18	Maine Critical Areas Program 1983b	No. 5 Bog					
18	Maine Critical Areas Program 1983b	Pine Stream Flowage					
18	Maine Critical Areas Program 1983b	Spencer Lake					
18	Maine Critical Areas Program 1983b	The Pines					
18	Maine Critical Areas Program 1983b	Wassataquoik Stream					
19	Methven 1973	Chalk River - Petewawa				38.8	>5 m tall
20	Milfred et al. 1967	Stand 04					
20	Milfred et al. 1967	Stand 10					
20	Milfred et al. 1967	Stand 35					
21	Morey 1936b	Hearts Content					

(Table 71 continued on next page)

(Table 71 continued)

Map Key	Source/Date	Stand	Live Tree Basal Area (BA)				
			≥10 cm (m²/ha)	≥50 cm (m²/ha)	≥70 cm (m²/ha)	≥X cm (m²/ha)	Min Diam X (cm)
22	Ohmann and Ream 1971b	Jack Pine (Oak)--11 Stands	20[3]				
22	Ohmann and Ream 1971b	Jack Pine (Fir)--7 Stands	25[4]				
22	Ohmann and Ream 1971b	Mixed Pine-Black Spruce--7 Stands	20[3]				
22	Ohmann and Ream 1971b	Red Pine--4 Stands	47[5]				
22	Ohmann and Ream 1971b	White Pine--6 Stands	35.1[5]				
23	Peet 1984	Lake Itasca--1957				20.1	2.54
23	Peet 1984	Lake Itasca--1983				19.5	2.54
24	Pinette and Rowe 1987	May Mountain				32.4	unspecified
24	Pinette and Rowe 1987	Snowshoe Pond				48.2	unspecified
24	Pinette and Rowe 1987	Squa Pau Lake				48.2	unspecified
25	Quinby 1988a	Temagami--Wakimika Triangle Area					
25	Quinby 1988a	Temagami--Red Pine	41.6				
25	Quinby 1988a	Temagami--White Pine-Black Spruce	28.6				
25	Quinby 1988a	Temagami--White Pine-Cedar	43.8				
25	Quinby 1988a	Temagami--White Pine-Jack Pine	29.6				
25	Quinby 1988a	Temagami--White Pine-Populus	34.5				
25	Quinby 1988a	Temagami--White Pine-Red Pine	36.1				
25	Quinby 1988a	Temagami--White Pine-White Birch	27.7				
26	Quinby 1988b	Algonquin Park--Jack Pine Type				24.6	2
26	Quinby 1988b	Algonquin Park--Red Pine Type				43.1	2
26	Quinby 1988b	Algonquin Park--White Pine Type				44.7	2
27	Quinby 1991	Temagami--Wakimika Triangle Area	32.8				
28	Robertson and Tiedje 1984	Hartwick Pines					
29	Roman 1980	Five Ponds Wilderness-Upland Conifer	44.5[6]				
29	Roman 1980	Five Ponds Wilderness--Plot 5	53.9				
29	Roman 1980	Five Ponds Wilderness--Plot 17	39.7				
29	Roman 1980	Five Ponds Wilderness--Plot 52	49.7				
29	Roman 1980	Five Ponds Wilderness--Plot 64	34.9				
30	Rose 1984	Hartwick Pines				72.6	>1.5m high
31	Shirley 1932	Cass Lake/Pike Bay					
32	Stai and Mladenoff 1993	August Lake	39.1	13.1	0		
32	Stai and Mladenoff 1993	Bohall Lake	54.1	8.4	0		
32	Stai and Mladenoff 1993	Burns Lake	71.1	44.4	14.6		
32	Stai and Mladenoff 1993	Coon Lake 20	54.6	45.1	18.0		
32	Stai and Mladenoff 1993	Hegman Lake	32.9	24.3	0		
32	Stai and Mladenoff 1993	Loon Lake	60.4	46.6	23.6		
32	Stai and Mladenoff 1993	Lost 40	49.6	44.3	27.8		

(Table 71 continued on next page)

(*Table 71 continued*)

Map Key	Source/Date	Stand	Live Tree Basal Area (BA)				
			$\geq$10 cm (m^2/ha)	$\geq$50 cm (m^2/ha)	$\geq$70 cm (m^2/ha)	$\geq$X cm (m^2/ha)	Min Diam X (cm)
32	Stai and Mladenoff 1993	Nicollet Trail	57.6	43.0	4.2		
32	Stai and Mladenoff 1993	Onigum	54.4	37.7	22.2		
32	Stai and Mladenoff 1993	Pine Point	36.7	25.4	12.6		
32	Stai and Mladenoff 1993	Sandwick Lake	51.9	45.9	40.7		
32	Stai and Mladenoff 1993	Sewage Pond	41.2	23.0	3.9		
32	Stai and Mladenoff 1993	Snail Lake	56.7	43.8	4.7		
32	Stai and Mladenoff 1993	Trout Lake	46.3	31.9	0		
32	Stai and Mladenoff 1993	Twomey Williams Road	76.6	55.9	41.2		
32	Stai and Mladenoff 1993	Voyageur Island	39.3	16.5	0		
33	Stearns 1950	Gillen Refuge/Plum Lake				83.8	2.5

[1] Basal area is for red pine only (red pine is >80% of stand density).

[2] Estimate of basal area calculated using size frequency distribution, converting diameter to basal area and summarizing by size classes.

[3] Basal area for jack pine and black spruce only.

[4] Basal area for jack pine, balsam fir, and black spruce only.

[5] Basal area for red and white pine only.

[6] Average of values for 4 upland conifer stands.

Table 72.—*Average and maximum tree age by species for northern pine old-growth study sites. Abbreviations for tree species are as follows: H, eastern hemlock; RS, red spruce.*

Map Key	Source/Date	Stand	---------Average Tree Age (yr)---------			---------------Maximum Tree Age (yr)---------------			
			Eastern White Pine	Red Pine	Jack Pine	Eastern White Pine	Red Pine	Jack Pine	Other
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 1	169	201		173	203		
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 2	180	194		215	210		
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 3	189	183		211	214		
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 4	157	191		240	260		
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 5	154	148		285	194		
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 6	175	173		256	205		
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 7	159			257			
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 8	158	164		186	164		
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 1	127	170		166	208		
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 2	125	197		309	283		
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 3	144	213		230	315		
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 4	265	229		321	289		
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 1	225			304			
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 2	222	259		342	259		
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 3	209			385			
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 4	207	178		268	178		
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 5	162			198			
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 6	236	189		352	189		
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 7	223			388			
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 2	229			331			
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 3	237			325			
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 8	258			271			
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 1		132			205		
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 2	84	119		116	236		
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 3	105	130		165	216		
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 4	179	159		189	286		
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 5	82			138			
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 6	82	136		96	181		
2	Baldwin 1951	Bradford				153			
3	Bergman 1924	Areas in Northern Minnesota				[1]	[1]		
4	Bourdo 1961	Baraga County	141			147			
5	Collins 1958	East Crawford County		~135			135-139		
5	Collins 1958	East Roscommon		[2]			195-199		
5	Collins 1958	Hartwick Pines		~185		146	195-199		
5	Collins 1958	Higgins Lake		~150			175-179		
5	Collins 1958	Houghton Lake		~130			140-144		
5	Collins 1958	Interlochen		~240			290-294		

(Table 72 continued on next page)

(Table 72 continued)

Map Key	Source/Date	Stand	Average Tree Age (yr)			Maximum Tree Age (yr)			
			Eastern White Pine	Red Pine	Jack Pine	Eastern White Pine	Red Pine	Jack Pine	Other
5	Collins 1958	Lake County		~160			180-184		
5	Collins 1958	Ogemaw County		~135			140-144		
5	Collins 1958	Presque Isle		~160			170-174		
5	Collins 1958	South Grayling		~150			180-184		
6	Conkling 1978	Corrina				145			
6	Conkling 1978	Eagle Lake							
6	Conkling 1978	Falmouth Interchange				150			
6	Conkling 1978	Mullen Woods				150			
6	Conkling 1978	Pennesseewassee Lake--Stand I				205			
6	Conkling 1978	Pennesseewassee Lake--Stand II				115			
6	Conkling 1978	Presumpscot River				135			
6	Conkling 1978	Salsbury Cove				185			
7	Duvall 1997	Finnerud (108/109)		152			163		
7	Duvall 1997	Hoist Lakes--C-97, St-40 (85)		~120[3]					
7	Duvall 1997	Holloway Road--C-101, St-4 (83)		~100[3]					
7	Duvall 1997	Indian River--C-18, St-26 (119)		~152[3]					
7	Duvall 1997	Lost 40--Oldest Stand (112)		178			215		
7	Duvall 1997	Lost 40--Younger Stand (121)		131			200		
7	Duvall 1997	Nordhouse Dunes (123)		90			95		
7	Duvall 1997	Squaw Creek--C-24, St-29 (110)		~150[3]					
7	Duvall 1997	Squirrel River (106)		118			143		
7	Duvall 1997	Tomahawk River (107)		134			136		
7	Duvall 1997	Valley Road--C-123, St-31 (82)		~103[3]					
7	Duvall 1997	Westlake--C-87, St-11 (111)		~132[3]					
7	Duvall 1997	Wilber--C-100, St-13 (84)		~112[3]					
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--1		120					
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--2		140					
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--3		160					
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--1		120					
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--2		140					
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--3		160					
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--1		120					
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--2		140					
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--3		160					
9	Graves 1899	Round Pond Township 23							
10	Heinselman 1973	Amoeber Lake--Plot 11			142				
10	Heinselman 1973	Cash Lake--Plot 32			124				

(Table 72 continued on next page)

(Table 72 continued)

Map Key	Source/Date	Stand	Average Tree Age (yr)			Maximum Tree Age (yr)			
			Eastern White Pine	Red Pine	Jack Pine	Eastern White Pine	Red Pine	Jack Pine	Other
10	Heinselman 1973	Echo Trail--Plot 29			215				
10	Heinselman 1973	Ester Lake--Plot 15			105				
10	Heinselman 1973	Insula Lake--Plot 25			105				
10	Heinselman 1973	Keeley Creek--Plot 27			116				
10	Heinselman 1973	Moose River, S.--Plot 3			105				
10	Heinselman 1973	North Hegman Lake--Plot 28			148				
10	Heinselman 1973	Seagull Lake--Plot 6			168				
10	Heinselman 1973	Seagull Lake--Plot 7			168				
10	Heinselman 1973	Stand A-5, Gaskin Lake	368						
10	Heinselman 1973	Stand A-8, Boulder Bay, Lac La Croix		283					
11	Holla and Knowles 1988	Sandford Lake	140[4]			188			
12	Hough and Forbes 1943	Cook Forest	290[5]			450			
12	Hough and Forbes 1943	East Tionesta Forest--Plot 8	~280-290			290			H-290
12	Hough and Forbes 1943	East Tionesta Forest--Plot 9	123			123			H-320
13	Iles 1990	Core 1/Tikamaganda Lake--White Pine	155[6]			160			
13	Iles 1990	Core 2/Galloway Lake--White Pine	156[6]			200			
13	Iles 1990	Core 3/Bliss Lake--White Pine	158[6]			180			
13	Iles 1990	Core 4/Quinn Lake--White Pine	160[6]			189			
13	Iles 1990	Core 5/Bark Lake--Jack Pine			91[6]				
13	Iles 1990	Core 5/Bark Lake--Red Pine		175[6]			195		
13	Iles 1990	Core 5/Bark Lake--White Pine	170[6]			195			
13	Iles 1990	Core 6/Dave Lake--Jack Pine			86[6]				
13	Iles 1990	Core 6/Dave Lake--Red Pine		116[6]					
13	Iles 1990	Core 6/Dave Lake--White Pine	156[6]			176			
13	Iles 1990	Core 7/Rushbrook Lake--Jack Pine			106[6]				
13	Iles 1990	Core 7/Rushbrook Lake--White Pine	151[6]			166			
13	Iles 1990	Core 8/Wolf Lake--Jack Pine			139[6]				
13	Iles 1990	Core 8/Wolf Lake--Red Pine		165[6]			210		
13	Iles 1990	Core 9/Obabika Lake--Red Pine		169[6]			193		
13	Iles 1990	Core 9/Obabika Lake--White Pine	196[6]						
13	Iles 1990	Core 10/Kokoko Bay--Red Pine		177[6]			206		
13	Iles 1990	Core 10/Kokoko Bay--White Pine	194[6]			221			
14	Kittredge 1934	Star Island--East Transitional Stand	250	250					
14	Kittredge 1934	Star Island--NW Windigo Jack Pine			100			120	
14	Kittredge 1934	Star Island--NW Windigo Norway Pine		200					
14	Kittredge 1934	Star Island--White Pine							
15	Kittredge and Chittenden 1929	Interlochen State Park							

(Table 72 continued on next page)

(Table 72 continued)

Map Key	Source/Date	Stand	Average Tree Age (yr) Eastern White Pine	Average Tree Age (yr) Red Pine	Average Tree Age (yr) Jack Pine	Maximum Tree Age (yr) Eastern White Pine	Maximum Tree Age (yr) Red Pine	Maximum Tree Age (yr) Jack Pine	Other
16	Lutz and McComb 1935	Ludlow							
17	Maine Critical Areas Program 1983a	Attean Pond			31-126			126	
17	Maine Critical Areas Program 1983a	Big Island - Lobster Lake						168	
17	Maine Critical Areas Program 1983a	Bradstreet Jack Pine Natural Area			55-65		204	96 [7]	
17	Maine Critical Areas Program 1983a	Cadillac Mountain			75-78 [8]			78	
17	Maine Critical Areas Program 1983a	Dyer Neck						100+	
17	Maine Critical Areas Program 1983a	First Debsconeag Lake			73-153 [9]			153	
17	Maine Critical Areas Program 1983a	Great Wass Island						110-140 [10]	
17	Maine Critical Areas Program 1983a	Holeb Pond						90	
17	Maine Critical Areas Program 1983a	Louse Island - Matagamon Lake						[11]	
17	Maine Critical Areas Program 1983a	North of Schoodic Trail			100-120			120	
17	Maine Critical Areas Program 1983a	Passamagamet			110-117			117	
17	Maine Critical Areas Program 1983a	Schoodic Peninsula						95+ [12]	
17	Maine Critical Areas Program 1983a	Umbagog Lake						80	
17	Maine Critical Areas Program 1983a	Wonsqueak			105				
18	Maine Critical Areas Program 1983b	Baker Pond					120		
18	Maine Critical Areas Program 1983b	Bald Mountain	150 [13]						
18	Maine Critical Areas Program 1983b	Big Island - Lobster Lake					172		
18	Maine Critical Areas Program 1983b	Cathedral Pines		180-200 [9]			200		
18	Maine Critical Areas Program 1983b	Chesuncook Lake	250			406			
18	Maine Critical Areas Program 1983b	Cliff Ridge	148 [14]	133 [14]		191	144		
18	Maine Critical Areas Program 1983b	Debsconeag Lake					188 [15]	[15]	
18	Maine Critical Areas Program 1983b	Gero Island	150-200			200			
18	Maine Critical Areas Program 1983b	Hollis				160+ [16]			
18	Maine Critical Areas Program 1983b	Huston Brook				250-300 [17]			
18	Maine Critical Areas Program 1983b	Moosehorn Stream				150			RS-200
18	Maine Critical Areas Program 1983b	Newcastle	200 [13]						
18	Maine Critical Areas Program 1983b	No. 5 Bog		220			220		RS-95
18	Maine Critical Areas Program 1983b	Pine Stream Flowage	220 [18]			270+ [18]			RS-88
18	Maine Critical Areas Program 1983b	Spencer Lake	160						
18	Maine Critical Areas Program 1983b	The Pines					250		
18	Maine Critical Areas Program 1983b	Wassataquoik Stream				150+ [19]			
19	Methven 1973	Chalk River - Petewawa							
20	Milfred et al. 1967	Stand 04	350						
20	Milfred et al. 1967	Stand 10	130						
20	Milfred et al. 1967	Stand 35	130						
21	Morey 1936b	Hearts Content				330			

(Table 72 continued on next page)

(Table 72 continued)

			Average Tree Age (yr)			Maximum Tree Age (yr)			
Map Key	**Source/Date**	**Stand**	**Eastern White Pine**	**Red Pine**	**Jack Pine**	**Eastern White Pine**	**Red Pine**	**Jack Pine**	**Other**
22	Ohmann and Ream 1971b	Jack Pine (Oak)--11 Stands			60-105			107	
22	Ohmann and Ream 1971b	Jack Pine (Fir)--7 Stands							
22	Ohmann and Ream 1971b	Mixed Pine-Black Spruce--7 Stands							
22	Ohmann and Ream 1971b	Red Pine--4 Stands							
22	Ohmann and Ream 1971b	White Pine--6 Stands	96-107	96-107		291			
23	Peet 1984	Lake Itasca--1957							
23	Peet 1984	Lake Itasca--1983							
24	Pinette and Rowe 1987	May Mountain	162			185			
24	Pinette and Rowe 1987	Snowshoe Pond	185			291+			
24	Pinette and Rowe 1987	Squa Pau Lake	84			94			
25	Quinby 1988a	Temagami--Wakimika Triangle Area				~375	321		
25	Quinby 1988a	Temagami--Red Pine							
25	Quinby 1988a	Temagami--White Pine-Black Spruce							
25	Quinby 1988a	Temagami--White Pine-Cedar							
25	Quinby 1988a	Temagami--White Pine-Jack Pine							
25	Quinby 1988a	Temagami--White Pine-Populus							
25	Quinby 1988a	Temagami--White Pine-Red Pine							
25	Quinby 1988a	Temagami--White Pine-White Birch							
26	Quinby 1988b	Algonquin Park--Jack Pine Type							
26	Quinby 1988b	Algonquin Park--Red Pine Type							
26	Quinby 1988b	Algonquin Park--White Pine Type							
27	Quinby 1991	Temagami--Wakimika Triangle Area							
28	Robertson and Tiedje 1984	Hartwick Pines				>300			
29	Roman 1980	Five Ponds Wilderness-Upland Conifer							
29	Roman 1980	Five Ponds Wilderness--Plot 5							
29	Roman 1980	Five Ponds Wilderness--Plot 17							
29	Roman 1980	Five Ponds Wilderness--Plot 52							
29	Roman 1980	Five Ponds Wilderness--Plot 64							
30	Rose 1984	Hartwick Pines	177			229			
31	Shirley 1932	Cass Lake/Pike Bay		200+					
32	Stai and Mladenoff 1993	August Lake				229	296		
32	Stai and Mladenoff 1993	Bohall Lake					177		
32	Stai and Mladenoff 1993	Burns Lake					228		
32	Stai and Mladenoff 1993	Coon Lake 20					228		
32	Stai and Mladenoff 1993	Hegman Lake					179		
32	Stai and Mladenoff 1993	Loon Lake				204			
32	Stai and Mladenoff 1993	Lost 40					231		

(Table 72 continued on next page)

(Table 72 continued)

Map			Average Tree Age (yr)			Maximum Tree Age (yr)			
Key	Source/Date	Stand	Eastern White Pine	Red Pine	Jack Pine	Eastern White Pine	Red Pine	Jack Pine	Other
32	Stai and Mladenoff 1993	Nicollet Trail				189	193		
32	Stai and Mladenoff 1993	Onigum				158	158		
32	Stai and Mladenoff 1993	Pine Point					290		
32	Stai and Mladenoff 1993	Sandwick Lake				203			
32	Stai and Mladenoff 1993	Sewage Pond					219		
32	Stai and Mladenoff 1993	Snail Lake				166	166		
32	Stai and Mladenoff 1993	Trout Lake					234		
32	Stai and Mladenoff 1993	Twomey Williams Road				273	271		
32	Stai and Mladenoff 1993	Voyageur Island					326		
33	Stearns 1950	Gillen Refuge/Plum Lake	390						

[1] Red and white pines estimated to be 300-400 yr.

[2] Stand was two-aged: ~190 yr, ~115 yr.

[3] From year of origin stand information.

[4] Average age of white pine of all age classes: 52 yr; 140 yr for large pines.

[5] 290 yr is average age of bulk of white pine; some pre-fire veterans of 440-450 yr.

[6] Average age is a weighted average from the data base.

[7] Last documented fire in 1888; jack pine occurring there have reproduced, as ages are much younger.

[8] This stand has been typed jack pine since 1898, jack pine is apparently replacing itself.

[9] Range of ages; no average given.

[10] Maximum age varies with soil depth--on shallow soils, 110 yr; on deeper soils, 140 yr.

[11] Age of trees unknown, but Thoreau visited in 1868 and described as jack pine stand (The Maine Woods).

[12] Stands of jack pine known for Schoodic Peninsula since 1880's.

[13] Estimate of age.

[14] Average ages based on 5 red pine cores and 4 white pine cores.

[15] Age from cored trees; red pines and jack pines estimated to be 190-215 yr.

[16] Estimate of age based on ring count of 142.

[17] Estimate of maximum age class, based on ring count of 150 from outer 30 cm.

[18] Ages of white pines cored by Ed Cook, Columbia University is 140-270 yr; average for oldest trees was 220 yr. Cores of trees >51 cm taken in this study were incomplete due to hollow center.

[19] Maximum ring count was 143 from increment cores.

Table 73.—*Maximum tree diameter by species, average canopy height, and the percentage of the tree canopy in gaps for northern pine old-growth study sites. Abbreviations for tree species are as follows: BTA, bigtooth aspen; H, eastern hemlock; PB, paper birch; RM, red maple; RO, northern red oak; RS, red spruce; WC, northern white-cedar.*

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm) White Pine	Red Pine	Jack Pine	Other	Average Canopy Height (m)	Canopy Gaps (%)
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 1					26[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 2					26[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 3					26[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 4					25[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 5					19[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 6					27[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 7					25[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 8					30[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 1					14[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 2					14[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 3					18[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 4					23[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 1					24[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 2					17[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 3					25[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 4					28[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 5					23[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 6					23[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 7					27[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 2					28[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 3					24[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 8					29[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 1					16[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 2					14[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 3					15[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 4					21[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 5					22[1]	
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 6					18[1]	
2	Baldwin 1951	Bradford	125				40[2]	
3	Bergman 1924	Areas in Northern Minnesota	>75					
4	Bourdo 1961	Baraga County	86	71		[3]		
5	Collins 1958	East Crawford County					24	
5	Collins 1958	East Roscommon		72			23	
5	Collins 1958	Hartwick Pines					33	
5	Collins 1958	Higgins Lake	81				26	
5	Collins 1958	Houghton Lake					21	
5	Collins 1958	Interlochen					23	

(Table 73 continued on next page)

(Table 73 continued)

Map Key	Source/Date	Stand	----------Maximum Tree Diameter (cm)---------- White Pine	Red Pine	Jack Pine	Other	Average Canopy Height (m)	Canopy Gaps (%)
5	Collins 1958	Lake County					25	
5	Collins 1958	Ogemaw County					23	
5	Collins 1958	Presque Isle					29	
5	Collins 1958	South Grayling					26	
6	Conkling 1978	Corrina	86			[4]	37	
6	Conkling 1978	Eagle Lake				[5]	40	
6	Conkling 1978	Falmouth Interchange				[6]	26	
6	Conkling 1978	Mullen Woods	107			[7]	32	
6	Conkling 1978	Pennesseewassee Lake--Stand I				[8]	29	
6	Conkling 1978	Pennesseewassee Lake--Stand II				[9]	24	
6	Conkling 1978	Presumpscot River	86			[10]	34	
6	Conkling 1978	Salsbury Cove	86			[11]	24	
7	Duvall 1997	Finnerud (108/109)	68	54		BTA-43		
7	Duvall 1997	Hoist Lakes--C-97, St-40 (85)		71	30	BTA-59		
7	Duvall 1997	Holloway Road--C-101, St-4 (83)		60	25	RO-36		
7	Duvall 1997	Indian River--C-18, St-26 (119)	79	66	31			
7	Duvall 1997	Lost 40--Oldest Stand (112)	109	81		BTA-53		
7	Duvall 1997	Lost 40--Younger Stand (121)	78	58				
7	Duvall 1997	Nordhouse Dunes (123)		45	32			
7	Duvall 1997	Squaw Creek--C-24, St-29 (110)	69	59				
7	Duvall 1997	Squirrel River (106)	60	71				
7	Duvall 1997	Tomahawk River (107)	66	66				
7	Duvall 1997	Valley Road--C-123, St-31 (82)						
7	Duvall 1997	Westlake--C-87, St-11 (111)		48				
7	Duvall 1997	Wilber--C-100, St-13 (84)	83	60		RM-43		
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--1						
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--2						
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--3						
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--1						
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--2						
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--3						
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--1						
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--2						
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--3						
9	Graves 1899	Round Pond Township 23	140				47 [12]	
10	Heinselman 1973	Amoeber Lake--Plot 11						
10	Heinselman 1973	Cash Lake--Plot 32						

(Table 73 continued on next page)

(Table 73 continued)

Map Key	Source/Date	Stand	----------Maximum Tree Diameter (cm)---------				Average Canopy Height (m)	Canopy Gaps (%)
			White Pine	Red Pine	Jack Pine	Other		
10	Heinselman 1973	Echo Trail--Plot 29						
10	Heinselman 1973	Ester Lake--Plot 15						
10	Heinselman 1973	Insula Lake--Plot 25						
10	Heinselman 1973	Keeley Creek--Plot 27						
10	Heinselman 1973	Moose River, S.--Plot 3						
10	Heinselman 1973	North Hegman Lake--Plot 28						
10	Heinselman 1973	Seagull Lake--Plot 6						
10	Heinselman 1973	Seagull Lake--Plot 7						
10	Heinselman 1973	Stand A-5, Gaskin Lake	104			[13]		
10	Heinselman 1973	Stand A-8, Boulder Bay, Lac La Croix	36	56				
11	Holla and Knowles 1988	Sandford Lake	90					
12	Hough and Forbes 1943	Cook Forest						
12	Hough and Forbes 1943	East Tionesta Forest--Plot 8						
12	Hough and Forbes 1943	East Tionesta Forest--Plot 9						
13	Iles 1990	Core 1/Tikamaganda Lake--White Pine						
13	Iles 1990	Core 2/Galloway Lake--White Pine						
13	Iles 1990	Core 3/Bliss Lake--White Pine						
13	Iles 1990	Core 4/Quinn Lake--White Pine						
13	Iles 1990	Core 5/Bark Lake--Jack Pine						
13	Iles 1990	Core 5/Bark Lake--Red Pine						
13	Iles 1990	Core 5/Bark Lake--White Pine						
13	Iles 1990	Core 6/Dave Lake--Jack Pine						
13	Iles 1990	Core 6/Dave Lake--Red Pine						
13	Iles 1990	Core 6/Dave Lake--White Pine						
13	Iles 1990	Core 7/Rushbrook Lake--Jack Pine						
13	Iles 1990	Core 7/Rushbrook Lake--White Pine						
13	Iles 1990	Core 8/Wolf Lake--Jack Pine						
13	Iles 1990	Core 8/Wolf Lake--Red Pine						
13	Iles 1990	Core 9/Obabika Lake--Red Pine						
13	Iles 1990	Core 9/Obabika Lake--White Pine						
13	Iles 1990	Core 10/Kokoko Bay--Red Pine						
13	Iles 1990	Core 10/Kokoko Bay--White Pine						
14	Kittredge 1934	Star Island--East Transitional Stand	86	71			38	
14	Kittredge 1934	Star Island--NW Windigo Jack Pine		31	36		26	
14	Kittredge 1934	Star Island--NW Windigo Norway Pine		56			30	
14	Kittredge 1934	Star Island--White Pine	66	41				
15	Kittredge and Chittenden 1929	Interlochen State Park						

(Table 73 continued on next page)

(Table 73 continued)

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm) White Pine	Red Pine	Jack Pine	Other	Average Canopy Height (m)	Canopy Gaps (%)
16	Lutz and McComb 1935	Ludlow						
17	Maine Critical Areas Program 1983a	Attean Pond			48		4.5-16.7	
17	Maine Critical Areas Program 1983a	Big Island - Lobster Lake			55			
17	Maine Critical Areas Program 1983a	Bradstreet Jack Pine Natural Area		48				
17	Maine Critical Areas Program 1983a	Cadillac Mountain			25		1.2-7.6	
17	Maine Critical Areas Program 1983a	Dyer Neck			31			
17	Maine Critical Areas Program 1983a	First Debsconeag Lake			51	WC-46	8	
17	Maine Critical Areas Program 1983a	Great Wass Island			25-36 [14]		6-11 [14]	
17	Maine Critical Areas Program 1983a	Holeb Pond			33		15	
17	Maine Critical Areas Program 1983a	Louse Island - Matagamon Lake			38		15	
17	Maine Critical Areas Program 1983a	North of Schoodic Trail			31		4.6-7.6	
17	Maine Critical Areas Program 1983a	Passamagamet			48		11	
17	Maine Critical Areas Program 1983a	Schoodic Peninsula			28			
17	Maine Critical Areas Program 1983a	Umbagog Lake			41		6-9	
17	Maine Critical Areas Program 1983a	Wonsqueak			31		12-15	
18	Maine Critical Areas Program 1983b	Baker Pond		51		RS-25		
18	Maine Critical Areas Program 1983b	Bald Mountain	94					
18	Maine Critical Areas Program 1983b	Big Island - Lobster Lake		51				
18	Maine Critical Areas Program 1983b	Cathedral Pines						
18	Maine Critical Areas Program 1983b	Chesuncook Lake	86				27-30	
18	Maine Critical Areas Program 1983b	Cliff Ridge	51	51			14-18	
18	Maine Critical Areas Program 1983b	Debsconeag Lake	48	53			20-21	
18	Maine Critical Areas Program 1983b	Gero Island	96				30-36	
18	Maine Critical Areas Program 1983b	Hollis	94			H-53	27 [15]	
18	Maine Critical Areas Program 1983b	Huston Brook	127					
18	Maine Critical Areas Program 1983b	Moosehorn Stream	79			RS-56		
18	Maine Critical Areas Program 1983b	Newcastle	109				30 [16]	
18	Maine Critical Areas Program 1983b	No. 5 Bog		64		RS-31		
18	Maine Critical Areas Program 1983b	Pine Stream Flowage	114					
18	Maine Critical Areas Program 1983b	Spencer Lake	41					
18	Maine Critical Areas Program 1983b	The Pines	76	53				
18	Maine Critical Areas Program 1983b	Wassataquoik Stream	107				32	
19	Methven 1973	Chalk River - Petewawa						
20	Milfred et al. 1967	Stand 04						
20	Milfred et al. 1967	Stand 10						
20	Milfred et al. 1967	Stand 35						
21	Morey 1936b	Hearts Content	126 [17]				49 [18]	

(Table 73 continued on next page)

(Table 73 continued)

Map Key	Source/Date	Stand	----------Maximum Tree Diameter (cm)----------				Average Canopy Height (m)	Canopy Gaps (%)
			White Pine	Red Pine	Jack Pine	Other		
22	Ohmann and Ream 1971b	Jack Pine (Oak)--11 Stands						
22	Ohmann and Ream 1971b	Jack Pine (Fir)--7 Stands						
22	Ohmann and Ream 1971b	Mixed Pine-Black Spruce--7 Stands						
22	Ohmann and Ream 1971b	Red Pine--4 Stands						
22	Ohmann and Ream 1971b	White Pine--6 Stands						
23	Peet 1984	Lake Itasca--1957	90 [19]	90 [19]				
23	Peet 1984	Lake Itasca--1983	96 [19]	96 [19]				
24	Pinette and Rowe 1987	May Mountain	51				17, 27 [20]	
24	Pinette and Rowe 1987	Snowshoe Pond	114				up to 52 [21]	
24	Pinette and Rowe 1987	Squa Pau Lake	76				26	
25	Quinby 1988a	Temagami--Wakimika Triangle Area						
25	Quinby 1988a	Temagami--Red Pine						
25	Quinby 1988a	Temagami--White Pine-Black Spruce						
25	Quinby 1988a	Temagami--White Pine-Cedar						
25	Quinby 1988a	Temagami--White Pine-Jack Pine						
25	Quinby 1988a	Temagami--White Pine-Populus						
25	Quinby 1988a	Temagami--White Pine-Red Pine						
25	Quinby 1988a	Temagami--White Pine-White Birch						
26	Quinby 1988b	Algonquin Park--Jack Pine Type						
26	Quinby 1988b	Algonquin Park--Red Pine Type						
26	Quinby 1988b	Algonquin Park--White Pine Type						
27	Quinby 1991	Temagami--Wakimika Triangle Area	95-100					
28	Robertson and Tiedje 1984	Hartwick Pines						
29	Roman 1980	Five Ponds Wilderness-Upland Conifer	75					
29	Roman 1980	Five Ponds Wilderness--Plot 5	65-70					
29	Roman 1980	Five Ponds Wilderness--Plot 17						
29	Roman 1980	Five Ponds Wilderness--Plot 52						
29	Roman 1980	Five Ponds Wilderness--Plot 64						
30	Rose 1984	Hartwick Pines	110	60			38	6 [22]
31	Shirley 1932	Cass Lake/Pike Bay						
32	Stai and Mladenoff 1993	August Lake	57	60		PB-26		
32	Stai and Mladenoff 1993	Bohall Lake	23	53		PB-14		
32	Stai and Mladenoff 1993	Burns Lake	92	70		PB-26		
32	Stai and Mladenoff 1993	Coon Lake 20	83	72		PB-15		
32	Stai and Mladenoff 1993	Hegman Lake	69	66		PB-19		
32	Stai and Mladenoff 1993	Loon Lake	85	0		PB-42		
32	Stai and Mladenoff 1993	Lost 40	101	78		PB-22		

(Table 73 continued on next page)

(Table 73 continued)

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm)				Average Canopy Height (m)	Canopy Gaps (%)
			White Pine	Red Pine	Jack Pine	Other		
32	Stai and Mladenoff 1993	Nicollet Trail	73	57		PB-24		
32	Stai and Mladenoff 1993	Onigum	80	57		PB-35		
32	Stai and Mladenoff 1993	Pine Point	18	74		PB-26		
32	Stai and Mladenoff 1993	Sandwick Lake	84	42		PB-25		
32	Stai and Mladenoff 1993	Sewage Pond	70	60		PB-15		
32	Stai and Mladenoff 1993	Snail Lake	77	59		PB-19		
32	Stai and Mladenoff 1993	Trout Lake	0	65		PB-19		
32	Stai and Mladenoff 1993	Twomey Williams Road	91	92		PB-32		
32	Stai and Mladenoff 1993	Voyageur Island	67	56		PB-21		
33	Stearns 1950	Gillen Refuge/Plum Lake	102					

[1] Height values are for white pine.

[2] Height for largest pine.

[3] Other maximum diameters: American basswood 61 cm, paper birch 41 cm, yellow birch 41 cm, red maple 36 cm, eastern hemlock 41 cm, balsam fir 30 cm.

[4] Average diameter 58 cm.

[5] Average diameter 71 cm.

[6] Average diameter 66 cm.

[7] Average diameter 58 cm.

[8] Average diameter 81 cm.

[9] Average diameter 41 cm.

[10] Average diameter 61 cm.

[11] Average diameter 71 cm.

[12] Height of one large tree.

[13] white spruce 63, northern white-cedar 56, balsam fir 33, paper birch 41.

[14] Maximum diameter and height vary with soil depth--on shallow soils: 25 cm diameter, 6 m height; on deeper soils: 36 cm, 11 m.

[15] Average height for pine is 30 m; for eastern hemlock, 27 m.

[16] Height of white pine layer; oaks are 21-24 m tall.

[17] Maximum height in the "hemlock consociation".

[18] Maximum d.b.h in the "beech-hemlock association".

[19] Diameter size classes reported for white and red pine jointly.

[20] Height for most trees = 17m; for white pine in the overstory = 27 m.

[21] Height reported as approximately 170'.

[22] Structural gap area was 6%; functional gap area 15%.

Table 74.—*Density, basal area, volume, and minimum diameter measured for standing dead trees (snags) on northern pine old-growth study sites.*

			Standing Dead Trees (Snags)			
Map Key	Source/Date	Stand	Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Snag Volume (m^3/ha)	Min Snag Diam (cm)
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 1	119	2.6		10
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 2	85	3.7		10
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 3	86	3.8		10
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 4	101	3.9		10
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 5	110	3.6		10
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 6	101	3.7		10
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 7	98	4.9		10
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 8	160	7.3		10
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 1	54	0.89		10
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 2	95	3.6		10
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 3	110	3.9		10
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 4	164	6.5		10
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 1	108	4.0		10
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 2	92	3.3		10
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 3	94	4.5		10
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 4	82	3.0		10
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 5	109	5.1		10
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 6	104	4.2		10
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 7	139	5.3		10
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 2	36	2.3		10
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 3	35	3.4		10
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 8	35	2.8		10
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 1	122	4.5		10
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 2	199	6.6		10
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 3	122	3.6		10
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 4	126	3.6		10
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 5	99	0.5		10
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 6	155	3.9		10
2	Baldwin 1951	Bradford				
3	Bergman 1924	Areas in Northern Minnesota				
4	Bourdo 1961	Baraga County				
5	Collins 1958	East Crawford County				
5	Collins 1958	East Roscommon				
5	Collins 1958	Hartwick Pines				
5	Collins 1958	Higgins Lake				
5	Collins 1958	Houghton Lake				
5	Collins 1958	Interlochen				

(Table 74 continued on next page)

(Table 74 continued)

			Standing Dead Trees (Snags)			
Map Key	**Source/Date**	**Stand**	**Snag Density (#/ha)**	**Snag Basal Area (m^2/ha)**	**Snag Volume (m^3/ha)**	**Min Snag Diam (cm)**
5	Collins 1958	Lake County				
5	Collins 1958	Ogemaw County				
5	Collins 1958	Presque Isle				
5	Collins 1958	South Grayling				
6	Conkling 1978	Corrina				
6	Conkling 1978	Eagle Lake				
6	Conkling 1978	Falmouth Interchange				
6	Conkling 1978	Mullen Woods				
6	Conkling 1978	Pennesseewassee Lake--Stand I				
6	Conkling 1978	Pennesseewassee Lake--Stand II				
6	Conkling 1978	Presumpscot River				
6	Conkling 1978	Salsbury Cove				
7	Duvall 1997	Finnerud (108/109)	44	2.0	18.2	2.5
7	Duvall 1997	Hoist Lakes--C-97, St-40 (85)	228	6.9	50.1	2.5
7	Duvall 1997	Holloway Road--C-101, St-4 (83)	54	1.5	11.7	2.5
7	Duvall 1997	Indian River--C-18, St-26 (119)	10	1.1	13.3	2.5
7	Duvall 1997	Lost 40--Oldest Stand (112)	102	5.7	56.7	2.5
7	Duvall 1997	Lost 40--Younger Stand (121)	72	2.3	18.2	2.5
7	Duvall 1997	Nordhouse Dunes (123)	46	0.8	3.7	2.5
7	Duvall 1997	Squaw Creek--C-24, St-29 (110)	0	0	0	2.5
7	Duvall 1997	Squirrel River (106)	37	3.1	19.3	2.5
7	Duvall 1997	Tomahawk River (107)	402	3.4	21.6	2.5
7	Duvall 1997	Valley Road--C-123, St-31 (82)	399	3.4	24.2	2.5
7	Duvall 1997	Westlake--C-87, St-11 (111)	90	0.8	4.0	2.5
7	Duvall 1997	Wilber--C-100, St-13 (84)	65	1.5	12.3	2.5
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--1				
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--2				
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--3				
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--1				
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--2				
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--3				
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--1				
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--2				
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--3				
9	Graves 1899	Round Pond Township 23				
10	Heinselman 1973	Amoeber Lake--Plot 11				
10	Heinselman 1973	Cash Lake--Plot 32				

(Table 74 continued on next page)

(Table 74 continued)

Map Key	Source/Date	Stand	Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Snag Volume (m^3/ha)	Min Snag Diam (cm)
			Standing Dead Trees (Snags)			
10	Heinselman 1973	Echo Trail--Plot 29				
10	Heinselman 1973	Ester Lake--Plot 15				
10	Heinselman 1973	Insula Lake--Plot 25				
10	Heinselman 1973	Keeley Creek--Plot 27				
10	Heinselman 1973	Moose River, S.--Plot 3				
10	Heinselman 1973	North Hegman Lake--Plot 28				
10	Heinselman 1973	Seagull Lake--Plot 6				
10	Heinselman 1973	Seagull Lake--Plot 7				
10	Heinselman 1973	Stand A-5, Gaskin Lake				
10	Heinselman 1973	Stand A-8, Boulder Bay, Lac La Croix				
11	Holla and Knowles 1988	Sandford Lake				
12	Hough and Forbes 1943	Cook Forest				
12	Hough and Forbes 1943	East Tionesta Forest--Plot 8				
12	Hough and Forbes 1943	East Tionesta Forest--Plot 9				
13	Iles 1990	Core 1/Tikamaganda Lake--White Pine				
13	Iles 1990	Core 2/Galloway Lake--White Pine				
13	Iles 1990	Core 3/Bliss Lake--White Pine				
13	Iles 1990	Core 4/Quinn Lake--White Pine				
13	Iles 1990	Core 5/Bark Lake--Jack Pine				
13	Iles 1990	Core 5/Bark Lake--Red Pine				
13	Iles 1990	Core 5/Bark Lake--White Pine				
13	Iles 1990	Core 6/Dave Lake--Jack Pine				
13	Iles 1990	Core 6/Dave Lake--Red Pine				
13	Iles 1990	Core 6/Dave Lake--White Pine				
13	Iles 1990	Core 7/Rushbrook Lake--Jack Pine				
13	Iles 1990	Core 7/Rushbrook Lake--White Pine				
13	Iles 1990	Core 8/Wolf Lake--Jack Pine				
13	Iles 1990	Core 8/Wolf Lake--Red Pine				
13	Iles 1990	Core 9/Obabika Lake--Red Pine				
13	Iles 1990	Core 9/Obabika Lake--White Pine				
13	Iles 1990	Core 10/Kokoko Bay--Red Pine				
13	Iles 1990	Core 10/Kokoko Bay--White Pine				
14	Kittredge 1934	Star Island--East Transitional Stand				
14	Kittredge 1934	Star Island--NW Windigo Jack Pine				
14	Kittredge 1934	Star Island--NW Windigo Norway Pine				
14	Kittredge 1934	Star Island--White Pine				
15	Kittredge and Chittenden 1929	Interlochen State Park				

(Table 74 continued on next page)

(Table 74 continued)

Map Key	Source/Date	Stand	Standing Dead Trees (Snags)			
			Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Snag Volume (m^3/ha)	Min Snag Diam (cm)
16	Lutz and McComb 1935	Ludlow				
17	Maine Critical Areas Program 1983a	Attean Pond				
17	Maine Critical Areas Program 1983a	Big Island - Lobster Lake				
17	Maine Critical Areas Program 1983a	Bradstreet Jack Pine Natural Area				
17	Maine Critical Areas Program 1983a	Cadillac Mountain				
17	Maine Critical Areas Program 1983a	Dyer Neck				
17	Maine Critical Areas Program 1983a	First Debsconeag Lake				
17	Maine Critical Areas Program 1983a	Great Wass Island				
17	Maine Critical Areas Program 1983a	Holeb Pond				
17	Maine Critical Areas Program 1983a	Louse Island - Matagamon Lake				
17	Maine Critical Areas Program 1983a	North of Schoodic Trail				
17	Maine Critical Areas Program 1983a	Passamagamet				
17	Maine Critical Areas Program 1983a	Schoodic Peninsula				
17	Maine Critical Areas Program 1983a	Umbagog Lake				
17	Maine Critical Areas Program 1983a	Wonsqueak				
19	Maine Critical Areas Program 1983b	Baker Pond				
18	Maine Critical Areas Program 1983b	Bald Mountain				
18	Maine Critical Areas Program 1983b	Big Island - Lobster Lake				
18	Maine Critical Areas Program 1983b	Cathedral Pines				
18	Maine Critical Areas Program 1983b	Chesuncook Lake				
18	Maine Critical Areas Program 1983b	Cliff Ridge				
18	Maine Critical Areas Program 1983b	Debsconeag Lake				
18	Maine Critical Areas Program 1983b	Gero Island				
18	Maine Critical Areas Program 1983b	Hollis				
18	Maine Critical Areas Program 1983b	Huston Brook				
18	Maine Critical Areas Program 1983b	Moosehorn Stream				
18	Maine Critical Areas Program 1983b	Newcastle				
18	Maine Critical Areas Program 1983b	No. 5 Bog				
18	Maine Critical Areas Program 1983b	Pine Stream Flowage				
18	Maine Critical Areas Program 1983b	Spencer Lake				
18	Maine Critical Areas Program 1983b	The Pines				
18	Maine Critical Areas Program 1983b	Wassataquoik Stream				
19	Methven 1973	Chalk River - Petewawa				
20	Milfred et al. 1967	Stand 04				
20	Milfred et al. 1967	Stand 10				
20	Milfred et al. 1967	Stand 35				
21	Morey 1936b	Hearts Content				

(Table 74 continued on next page)

(Table 74 continued)

			Standing Dead Trees (Snags)			
Map Key	Source/Date	Stand	Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Snag Volume (m^3/ha)	Min Snag Diam (cm)
22	Ohmann and Ream 1971b	Jack Pine (Oak)--11 Stands				
22	Ohmann and Ream 1971b	Jack Pine (Fir)--7 Stands				
22	Ohmann and Ream 1971b	Mixed Pine-Black Spruce--7 Stands				
22	Ohmann and Ream 1971b	Red Pine--4 Stands				
22	Ohmann and Ream 1971b	White Pine--6 Stands				
23	Peet 1984	Lake Itasca--1957				
23	Peet 1984	Lake Itasca--1983	234			2.5
24	Pinette and Rowe 1987	May Mountain				
24	Pinette and Rowe 1987	Snowshoe Pond				
24	Pinette and Rowe 1987	Squa Pau Lake				
25	Quinby 1988a	Temagami--Wakimika Triangle Area				
25	Quinby 1988a	Temagami--Red Pine	139/138 (10) [1]	4.8		10
25	Quinby 1988a	Temagami--White Pine-Black Spruce	184/176 (46) [1]	7.2		10
25	Quinby 1988a	Temagami--White Pine-Cedar	142/140 (7) [1]	6.1		10
25	Quinby 1988a	Temagami--White Pine-Jack Pine	230/240 (10) [1]	10.4		10
25	Quinby 1988a	Temagami--White Pine-Populus	200/200 (50) [1]	7.9		10
25	Quinby 1988a	Temagami--White Pine-Red Pine	121/121 (17) [1]	6.8		10
25	Quinby 1988a	Temagami--White Pine-White Birch	158/158 (41) [1]	7.2		10
26	Quinby 1988b	Algonquin Park--Jack Pine Type				
26	Quinby 1988b	Algonquin Park--Red Pine Type				
26	Quinby 1988b	Algonquin Park--White Pine Type				
27	Quinby 1991	Temagami--Wakimika Triangle Area		7.4		10
28	Robertson and Tiedje 1984	Hartwick Pines				
29	Roman 1980	Five Ponds Wilderness-Upland Conifer				
29	Roman 1980	Five Ponds Wilderness--Plot 5		4.5		10
29	Roman 1980	Five Ponds Wilderness--Plot 17		3.2		10
29	Roman 1980	Five Ponds Wilderness--Plot 52		1.0		10
29	Roman 1980	Five Ponds Wilderness--Plot 64		2.6		10
30	Rose 1984	Hartwick Pines	22 [2]			unspecified
31	Shirley 1932	Cass Lake/Pike Bay	27			
32	Stai and Mladenoff 1993	August Lake	120 [3]		41.7 [3]	10/15 [4]
32	Stai and Mladenoff 1993	Bohall Lake	150 [5]		30.5 [5]	10/15 [4]
32	Stai and Mladenoff 1993	Burns Lake	60 [6]		9.1 [6]	10/15 [4]
32	Stai and Mladenoff 1993	Coon Lake 20	30 [7]		0 [7]	10/15 [4]
32	Stai and Mladenoff 1993	Hegman Lake	10 [8]		0 [8]	10/15 [4]
32	Stai and Mladenoff 1993	Loon Lake	160 [9]		87.6 [9]	10/15 [4]
32	Stai and Mladenoff 1993	Lost 40	70 [10]		21.0 [10]	10/15 [4]

(Table 74 continued on next page)

(Table 74 continued)

			Standing Dead Trees (Snags)			
Map Key	Source/Date	Stand	Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Snag Volume (m^3/ha)	Min Snag Diam (cm)
32	Stai and Mladenoff 1993	Nicollet Trail	40[11]		50.6[11]	10/15[4]
32	Stai and Mladenoff 1993	Onigum	60[12]		46.2[12]	10/15[4]
32	Stai and Mladenoff 1993	Pine Point	190[13]		119.2[13]	10/15[4]
32	Stai and Mladenoff 1993	Sandwick Lake	50[14]		14.2[14]	10/15[4]
32	Stai and Mladenoff 1993	Sewage Pond	70[15]		154.1[15]	10/15[4]
32	Stai and Mladenoff 1993	Snail Lake	80[16]		82.6[16]	10/15[4]
32	Stai and Mladenoff 1993	Trout Lake	140[17]		38.2[17]	10/15[4]
32	Stai and Mladenoff 1993	Twomey Williams Road	90[18]		119.6[18]	10/15[4]
32	Stai and Mladenoff 1993	Voyageur Island	200[19]		65.9[19]	10/15[4]
33	Stearns 1950	Gillen Refuge/Plum Lake				

[1] Values of snag volume computed from Quinby's Table 8 and Table 12 are not consistent. Number in parentheses is density of snags with holes.

[2] Density of snags is density of trees (size not specified) per ha that died creating gaps, as determined in study area.

[3] The density of snags of dominant species (red pine) only is 20/ha; the volume of snags of dominant species only is 39.2 m^2/ha.

[4] Minimum size for snags is 10 cm for density, 15 cm for volume.

[5] The density of snags of dominant species (red pine) only is 150/ha; the volume of snags of dominant species only is 30.5 m^2/ha.

[6] The density of snags of dominant species (red pine) only is 20/ha; the volume of snags of dominant species only is 6.8 m^2/ha.

[7] The density of snags of dominant species (red pine) only is 0/ha; the volume of snags of dominant species only is 0.0 m^2/ha.

[8] The density of snags of dominant species (red pine) only is 0/ha; the volume of snags of dominant species only is 0.0 m^2/ha.

[9] The density of snags of dominant species (red pine) only is 20/ha; the volume of snags of dominant species only is 35.2 m^2/ha.

[10] The density of snags of dominant species (red pine) only is 0/ha; the volume of snags of dominant species only is 0.0 m^2/ha.

[11] The density of snags of dominant species (red pine) only is 30/ha; the volume of snags of dominant species only is 47.2 m^2/ha.

[12] The density of snags of dominant species (red pine) only is 50/ha; the volume of snags of dominant species only is 46.2 m^2/ha.

[13] The density of snags of dominant species (red pine) only is 40/ha; the volume of snags of dominant species only is 90.9 m^2/ha.

[14] The density of snags of dominant species (red pine) only is 10/ha; the volume of snags of dominant species only is 11.0 m^2/ha.

[15] The density of snags of dominant species (red pine) only is 50/ha; the volume of snags of dominant species only is 153.9 m^2/ha.

[16] The density of snags of dominant species (red pine) only is 60/ha; the volume of snags of dominant species only is 80.4 m^2/ha.

[17] The density of snags of dominant species (red pine) only is 40/ha; the volume of snags of dominant species only is 37.1 m^2/ha.

[18] The density of snags of dominant species (red pine) only is 40/ha; the volume of snags of dominant species only is 117.5 m^2/ha.

[19] The density of snags of dominant species (red pine) only is 60/ha; the volume of snags of dominant species only is 63.3 m^2/ha.

Table 75.—*Density, volume, and minimum diameter measured for fallen dead trees (logs) and total volume of coarse woody debris (snags and logs) for northern pine old-growth study sites.*

			---------Fallen Dead Trees (Logs)---------			Total
Map Key	Source/Date	Stand	Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)	CWD Volume (m^3/ha)
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 1				
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 2				
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 3				
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 4				
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 5				
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 6				
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 7				
1	Arbex Forest Dev. Co. LTD. 1991	Bark Lake--Type 8				
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 1				
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 2				
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 3				
1	Arbex Forest Dev. Co. LTD. 1991	Obabika Lake--Type 4				
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 1				
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 2				
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 3				
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 4				
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 5				
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 6				
1	Arbex Forest Dev. Co. LTD. 1991	Quinn Lake--Type 7				
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 2				
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 3				
1	Arbex Forest Dev. Co. LTD. 1991	Tikamaganda Lake--Type 8				
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 1				
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 2				
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 3				
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 4				
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 5				
1	Arbex Forest Dev. Co. LTD. 1991	Wolf Lake--Type 6				
2	Baldwin 1951	Bradford				
3	Bergman 1924	Areas in Northern Minnesota				
4	Bourdo 1961	Baraga County				
5	Collins 1958	East Crawford County				
5	Collins 1958	East Roscommon				
5	Collins 1958	Hartwick Pines				
5	Collins 1958	Higgins Lake				
5	Collins 1958	Houghton Lake				
5	Collins 1958	Interlochen				

(Table 75 continued on next page)

(*Table 75 continued*)

Map Key	Source/Date	Stand	---------Fallen Dead Trees (Logs)---------			Total
			Density of Logs (#/ha)	Volume of Logs (m³/ha)	Min Diam Logs (cm)	CWD Volume (m³/ha)
5	Collins 1958	Lake County				
5	Collins 1958	Ogemaw County				
5	Collins 1958	Presque Isle				
5	Collins 1958	South Grayling				
6	Conkling 1978	Corrina				
6	Conkling 1978	Eagle Lake				
6	Conkling 1978	Falmouth Interchange				
6	Conkling 1978	Mullen Woods				
6	Conkling 1978	Pennesseewassee Lake--Stand I				
6	Conkling 1978	Pennesseewassee Lake--Stand II				
6	Conkling 1978	Presumpscot River				
6	Conkling 1978	Salsbury Cove				
7	Duvall 1997	Finnerud (108/109)		19.5	2.5	37.7 [1]
7	Duvall 1997	Hoist Lakes--C-97, St-40 (85)		42.3	2.5	92.3 [2]
7	Duvall 1997	Holloway Road--C-101, St-4 (83)		22.9	2.5	34.6 [3]
7	Duvall 1997	Indian River--C-18, St-26 (119)		6.9	2.5	20.2 [4]
7	Duvall 1997	Lost 40--Oldest Stand (112)		61.5	2.5	118.2 [5]
7	Duvall 1997	Lost 40--Younger Stand (121)		61.7	2.5	80.0 [6]
7	Duvall 1997	Nordhouse Dunes (123)		8.9	2.5	12.6 [7]
7	Duvall 1997	Squaw Creek--C-24, St-29 (110)		25.2	2.5	25.2 [8]
7	Duvall 1997	Squirrel River (106)		69.3	2.5	88.6 [9]
7	Duvall 1997	Tomahawk River (107)		6.7	2.5	28.3 [10]
7	Duvall 1997	Valley Road--C-123, St-31 (82)		43.8	2.5	68.0 [11]
7	Duvall 1997	Westlake--C-87, St-11 (111)		14.3	2.5	18.3 [12]
7	Duvall 1997	Wilber--C-100, St-13 (84)		18.0	2.5	30.3 [13]
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--1				
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--2				
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=40--3				
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--1				
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--2				
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=52--3				
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--1				
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--2				
8	Eyre and Zehngraff 1948	Minnesota Stand--Site Index=60--3				
9	Graves 1899	Round Pond Township 23				
10	Heinselman 1973	Amoeber Lake--Plot 11				
10	Heinselman 1973	Cash Lake--Plot 32				

(*Table 75 continued on next page*)

(Table 75 continued)

			Fallen Dead Trees (Logs)			
Map Key	Source/Date	Stand	Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)	Total CWD Volume (m^3/ha)
10	Heinselman 1973	Echo Trail--Plot 29				
10	Heinselman 1973	Ester Lake--Plot 15				
10	Heinselman 1973	Insula Lake--Plot 25				
10	Heinselman 1973	Keeley Creek--Plot 27				
10	Heinselman 1973	Moose River, S.--Plot 3				
10	Heinselman 1973	North Hegman Lake--Plot 28				
10	Heinselman 1973	Seagull Lake--Plot 6				
10	Heinselman 1973	Seagull Lake--Plot 7				
10	Heinselman 1973	Stand A-5, Gaskin Lake				
10	Heinselman 1973	Stand A-8, Boulder Bay, Lac La Croix				
11	Holla and Knowles 1988	Sandford Lake				
12	Hough and Forbes 1943	Cook Forest				
12	Hough and Forbes 1943	East Tionesta Forest--Plot 8				
12	Hough and Forbes 1943	East Tionesta Forest--Plot 9				
13	Iles 1990	Core 1/Tikamaganda Lake--White Pine				
13	Iles 1990	Core 2/Galloway Lake--White Pine				
13	Iles 1990	Core 3/Bliss Lake--White Pine				
13	Iles 1990	Core 4/Quinn Lake--White Pine				
13	Iles 1990	Core 5/Bark Lake--Jack Pine				
13	Iles 1990	Core 5/Bark Lake--Red Pine				
13	Iles 1990	Core 5/Bark Lake--White Pine				
13	Iles 1990	Core 6/Dave Lake--Jack Pine				
13	Iles 1990	Core 6/Dave Lake--Red Pine				
13	Iles 1990	Core 6/Dave Lake--White Pine				
13	Iles 1990	Core 7/Rushbrook Lake--Jack Pine				
13	Iles 1990	Core 7/Rushbrook Lake--White Pine				
13	Iles 1990	Core 8/Wolf Lake--Jack Pine				
13	Iles 1990	Core 8/Wolf Lake--Red Pine				
13	Iles 1990	Core 9/Obabika Lake--Red Pine				
13	Iles 1990	Core 9/Obabika Lake--White Pine				
13	Iles 1990	Core 10/Kokoko Bay--Red Pine				
13	Iles 1990	Core 10/Kokoko Bay--White Pine				
14	Kittredge 1934	Star Island--East Transitional Stand				
14	Kittredge 1934	Star Island--NW Windigo Jack Pine				
14	Kittredge 1934	Star Island--NW Windigo Norway Pine				
14	Kittredge 1934	Star Island--White Pine				
15	Kittredge and Chittenden 1929	Interlochen State Park				

(Table 75 continued on next page)

(Table 75 continued)

			---------Fallen Dead Trees (Logs)--------			Total
Map Key	Source/Date	Stand	Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)	CWD Volume (m^3/ha)
16	Lutz and McComb 1935	Ludlow				
17	Maine Critical Areas Program 1983a	Attean Pond				
17	Maine Critical Areas Program 1983a	Big Island - Lobster Lake				
17	Maine Critical Areas Program 1983a	Bradstreet Jack Pine Natural Area				
17	Maine Critical Areas Program 1983a	Cadillac Mountain				
17	Maine Critical Areas Program 1983a	Dyer Neck				
17	Maine Critical Areas Program 1983a	First Debsconeag Lake				
17	Maine Critical Areas Program 1983a	Great Wass Island				
17	Maine Critical Areas Program 1983a	Holeb Pond				
17	Maine Critical Areas Program 1983a	Louse Island - Matagamon Lake				
17	Maine Critical Areas Program 1983a	North of Schoodic Trail				
17	Maine Critical Areas Program 1983a	Passamagamet				
17	Maine Critical Areas Program 1983a	Schoodic Peninsula				
17	Maine Critical Areas Program 1983a	Umbagog Lake				
17	Maine Critical Areas Program 1983a	Wonsqueak				
18	Maine Critical Areas Program 1983b	Baker Pond				
18	Maine Critical Areas Program 1983b	Bald Mountain				
18	Maine Critical Areas Program 1983b	Big Island - Lobster Lake				
18	Maine Critical Areas Program 1983b	Cathedral Pines				
18	Maine Critical Areas Program 1983b	Chesuncook Lake				
18	Maine Critical Areas Program 1983b	Cliff Ridge				
18	Maine Critical Areas Program 1983b	Debsconeag Lake				
18	Maine Critical Areas Program 1983b	Gero Island				
18	Maine Critical Areas Program 1983b	Hollis				
18	Maine Critical Areas Program 1983b	Huston Brook				
18	Maine Critical Areas Program 1983b	Moosehorn Stream				
18	Maine Critical Areas Program 1983b	Newcastle				
18	Maine Critical Areas Program 1983b	No. 5 Bog				
18	Maine Critical Areas Program 1983b	Pine Stream Flowage				
18	Maine Critical Areas Program 1983b	Spencer Lake				
18	Maine Critical Areas Program 1983b	The Pines				
18	Maine Critical Areas Program 1983b	Wassataquoik Stream				
19	Methven 1973	Chalk River - Petewawa				
20	Milfred et al. 1967	Stand 04				
20	Milfred et al. 1967	Stand 10				
20	Milfred et al. 1967	Stand 35				
21	Morey 1936b	Hearts Content				

(Table 75 continued on next page)

(Table 75 continued)

Map Key	Source/Date	Stand	---------Fallen Dead Trees (Logs)--------- Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)	Total CWD Volume (m^3/ha)
22	Ohmann and Ream 1971b	Jack Pine (Oak)--11 Stands				
22	Ohmann and Ream 1971b	Jack Pine (Fir)--7 Stands				
22	Ohmann and Ream 1971b	Mixed Pine-Black Spruce--7 Stands				
22	Ohmann and Ream 1971b	Red Pine--4 Stands				
22	Ohmann and Ream 1971b	White Pine--6 Stands				
23	Peet 1984	Lake Itasca--1957				
23	Peet 1984	Lake Itasca--1983				
24	Pinette and Rowe 1987	May Mountain				
24	Pinette and Rowe 1987	Snowshoe Pond				
24	Pinette and Rowe 1987	Squa Pau Lake				
25	Quinby 1988a	Temagami--Wakimika Triangle Area	215	68.7 [14]	15	
25	Quinby 1988a	Temagami--Red Pine		49.9	15	
25	Quinby 1988a	Temagami--White Pine-Black Spruce		64.6	15	
25	Quinby 1988a	Temagami--White Pine-Cedar		25.3	15	
25	Quinby 1988a	Temagami--White Pine-Jack Pine		36.4	15	
25	Quinby 1988a	Temagami--White Pine-Populus		19.5	15	
25	Quinby 1988a	Temagami--White Pine-Red Pine		81.3	15	
25	Quinby 1988a	Temagami--White Pine-White Birch		78.3	15	
26	Quinby 1988b	Algonquin Park--Jack Pine Type				
26	Quinby 1988b	Algonquin Park--Red Pine Type				
26	Quinby 1988b	Algonquin Park--White Pine Type				
27	Quinby 1991	Temagami--Wakimika Triangle Area		55.8	15	
28	Robertson and Tiedje 1984	Hartwick Pines				
29	Roman 1980	Five Ponds Wilderness-Upland Conifer				
29	Roman 1980	Five Ponds Wilderness--Plot 5				
29	Roman 1980	Five Ponds Wilderness--Plot 17				
29	Roman 1980	Five Ponds Wilderness--Plot 52				
29	Roman 1980	Five Ponds Wilderness--Plot 64				
30	Rose 1984	Hartwick Pines				
31	Shirley 1932	Cass Lake/Pike Bay				
32	Stai and Mladenoff 1993	August Lake		107.4 [15]	15	149.1 [15]
32	Stai and Mladenoff 1993	Bohall Lake		61.1 [16]	15	91.6 [16]
32	Stai and Mladenoff 1993	Burns Lake		50.3 [17]	15	59.5 [17]
32	Stai and Mladenoff 1993	Coon Lake 20		3.8 [18]	15	3.8 [18]
32	Stai and Mladenoff 1993	Hegman Lake		40.9 [19]	15	40.9 [19]
32	Stai and Mladenoff 1993	Loon Lake		66.3 [20]	15	153.8 [20]
32	Stai and Mladenoff 1993	Lost 40		27.2 [21]	15	48.2 [21]

(Table 75 continued on next page)

(Table 75 continued)

Map Key	Source/Date	Stand	---------Fallen Dead Trees (Logs)--------- Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)	Total CWD Volume (m^3/ha)
32	Stai and Mladenoff 1993	Nicollet Trail		91.7 [22]	15	142.3 [22]
32	Stai and Mladenoff 1993	Onigum		7.9 [23]	15	54.1 [23]
32	Stai and Mladenoff 1993	Pine Point		45.3 [24]	15	164.5 [24]
32	Stai and Mladenoff 1993	Sandwick Lake		183.0 [25]	15	197.2 [25]
32	Stai and Mladenoff 1993	Sewage Pond		9.0 [26]	15	163.2 [26]
32	Stai and Mladenoff 1993	Snail Lake		56.8 [27]	15	139.4 [27]
32	Stai and Mladenoff 1993	Trout Lake		59.1 [28]	15	97.2 [28]
32	Stai and Mladenoff 1993	Twomey Williams Road		21.5 [29]	15	141.0 [29]
32	Stai and Mladenoff 1993	Voyageur Island		82.9 [30]	15	148.8 [30]
33	Stearns 1950	Gillen Refuge/Plum Lake				

[1] Total CWD basal area is 172 m^2/ha.

[2] Total CWD basal area is 373 m^2/ha.

[3] Total CWD basal area is 238 m^2/ha.

[4] Total CWD basal area is 103 m^2/ha.

[5] Total CWD basal area is 470 m^2/ha.

[6] Total CWD basal area is 440 m^2/ha.

[7] Total CWD basal area is 141 m^2/ha.

[8] Total CWD basal area is 139 m^2/ha.

[9] Total CWD basal area is 332 m^2/ha.

[10] Total CWD basal area is 121 m^2/ha.

[11] Total CWD basal area is 368 m^2/ha.

[12] Total CWD basal area is 199 m^2/ha.

[13] Total CWD basal area is 166 m^2/ha.

[14] Log volume reported for white pine is 0.02-5.4.

[15] Volume of logs for dominant species only was 93.9 m^3/ha; total volume of snags and logs (CWD) for dominant species only was 133.1 m^3/ha.

[16] Volume of logs for dominant species only was 61.1 m^3/ha; total volume of snags and logs (CWD) for dominant species only was 91.6 m^3/ha.

[17] Volume of logs for dominant species only was 15.0 m^3/ha; total volume of snags and logs (CWD) for dominant species only was 21.7 m^3/ha.

[18] Volume of logs for dominant species only was 2.7 m^3/ha; total volume of snags and logs (CWD) for dominant species only was 2.7 m^3/ha.

[19] Volume of logs for dominant species only was 17.5 m^3/ha; total volume of snags and logs (CWD) for dominant species only was 17.5 m^3/ha.

[20] Volume of logs for dominant species only was 50.3 m^3/ha; total volume of snags and logs (CWD) for dominant species only was 85.5 m^3/ha.

[21] Volume of logs for dominant species only was 19.9 m^3/ha; total volume of snags and logs (CWD) for dominant species only was 19.9 m^3/ha.

[22] Volume of logs for dominant species only was 83.3 m^3/ha; total volume of snags and logs (CWD) for dominant species only was 130.5 m^3/ha.

[23] Volume of logs for dominant species only was 7.9 m^3/ha; total volume of snags and logs (CWD) for dominant species only was 54.1 m^3/ha.

[24] Volume of logs for dominant species only was 33.9 m^3/ha; total volume of snags and logs (CWD) for dominant species only was 124.9 m^3/ha.

[25] Volume of logs for dominant species only was 164.7 m^3/ha; total volume of snags and logs (CWD) for dominant species only was 175.7 m^3/ha.

[26] Volume of logs for dominant species only was 4.4 m^3/ha; total volume of snags and logs (CWD) for dominant species only was 158.3 m^3/ha.

[27] Volume of logs for dominant species only was 52.3 m^3/ha; total volume of snags and logs (CWD) for dominant species only was 132.8 m^3/ha.

[28] Volume of logs for dominant species only was 59.1 m^3/ha; total volume of snags and logs (CWD) for dominant species only was 96.2 m^3/ha.

[29] Volume of logs for dominant species only was 0.2 m^3/ha; total volume of snags and logs (CWD) for dominant species only was 117.7 m^3/ha.

[30] Volume of logs for dominant species only was 72.3 m^3/ha; total volume of snags and logs (CWD) for dominant species only was 135.6 m^3/ha.

Table 76.—*Summary of attributes for old-growth northern pine stands (from Tables 67 through 75).*

Attribute	**Range**	**References (Map Key)**
Live Tree Density (#/ha)		
- Trees ≥ 2.5 cm d.b.h.	541 - 2569	4, 10, 23
- Trees ≥ 10 cm d.b.h.	151 - 1479	1, 22, 29, 32, 33
- Trees ≥ 25 cm d.b.h.	59 - 494	5, 14, 15
- Trees ≥ 50 cm d.b.h.	0 - 188	14, 15, 20, 32
- Trees ≥ 70 cm d.b.h.	0 - 90	14, 15, 20, 32
- Not as specified above		2, 3, 8, 16, 19, 20, 25, 30, 33
Live Tree Basal Area (m^2/ha)		
- Trees ≥ 2.5 cm d.b.h.	19.5 - 83.8	10, 23, 33
- Trees ≥ 10 cm d.b.h.	27.7 - 76.6	22, 25, 27, 29, 32
- Trees ≥ 50 cm d.b.h.	8.4 - 55.9	32
- Trees ≥ 70 cm d.b.h.	0 - 41.2	32
- Not as specified above		2, 4, 7, 8, 15, 19, 24, 26, 30
Tree or Stand Age (yr)		
Average Age by Species		
- White Pine	82 - 350	1, 4, 10, 12, 13, 14, 18, 20, 22, 24, 30, 33
- Red Pine	90 - 283	1, 5, 7, 8, 10, 13, 14, 17, 18, 22, 31
- Jack Pine	31 - 215	10, 13, 14, 17
Maximum Age by Species		
- White Pine	94 - 450	1, 2, 3, 4, 5, 6, 12, 13, 18, 21, 22, 24, 25, 28, 30, 32
- Red Pine	95 - 326	1, 3, 5, 7, 13, 18, 25, 32
- Jack Pine	78 - 168	14, 17
- Eastern Hemlock	290 - 320	12
- Red Spruce	88 - 200	18
Maximum Tree Diameter at Breast Height by Species (cm)		
- White Pine	36 - 140	2, 3, 4, 5, 6, 7, 9, 10, 14, 17, 18, 21, 23, 24, 27, 29, 30, 32
- Red Pine	31 - 96	4, 5, 7, 10, 14, 18, 23, 30, 32
- Jack Pine	25 - 55	7, 14, 17
- White (Paper) Birch	14 - 42	4, 32
- Bigtooth Aspen	43 - 59	7

(Table 76 continued on next page)

(Table 76 continued)

Attribute	Range	References (Map Key)
Average Canopy Height (m)	1.2 - 52	1, 2, 5, 9, 14, 17, 18, 21, 24, 30
Canopy Gaps (%)	6	30
Standing Dead Trees (Snags)		
Snag Density (#/ha)		
- Snags ≥ 2.5 cm d.b.h.	0 - 402	7, 23
- Snags ≥ 10 cm d.b.h.	10 - 240	1, 25, 32
- Snags ≥ 10 cm d.b.h. (with holes)	7 - 50	25
Snag Basal Area (m^2/ha)		
- Snags ≥ 2.5 cm d.b.h.	0 - 6.9	7
- Snags ≥ 10 cm d.b.h.	0.89 - 10.9	1, 25, 27, 29
Snag Volume (m^3/ha)		
- Snags ≥ 2.5 cm d.b.h.	0 - 56.7	7
- Snags ≥ 15 cm d.b.h.	0 - 154.1	32
Fallen Dead Trees (Logs)		
Density of Logs (#/ha)		
- Logs ≥ 15 cm d.b.h.	215	25
Volume of Logs (m^3/ha)		
- Logs ≥ 2.5 cm d.b.h.	6.7 - 69.3	7
- Logs ≥ 15 cm d.b.h.	3.8 - 183.0	25, 27, 32
Total Volume of Coarse Woody Debris (Snags and Logs) (m3/ha)		
- Snags and Logs ≥ 2.5 cm	12.6 - 118.2	7
- Snags and Logs ≥ 15 cm	3.8 - 197.2	32

MONTANE AND ALLIED SPRUCE-FIR FORESTS

COMMUNITY COMPOSITION

Forest Cover Types

The following Society of American Foresters (SAF) forest cover types (Eyre 1980) are included in the montane spruce-fir forest type group:

montane
5 - balsam fir
32 - red spruce
33 - red spruce-balsam fir
34 - red spruce-Fraser fir
35 - paper birch-red spruce-balsam fir

Other forests are similar to montane spruce-fir forests because of similar growing conditions, mainly moisture. These forests are considered "allied" with montane spruce-fir forests. Falling into this category are spruce-fir forests in mountain wetlands, on lower slopes, and in coastal areas. The SAF types occurring on the allied groups are as follows:

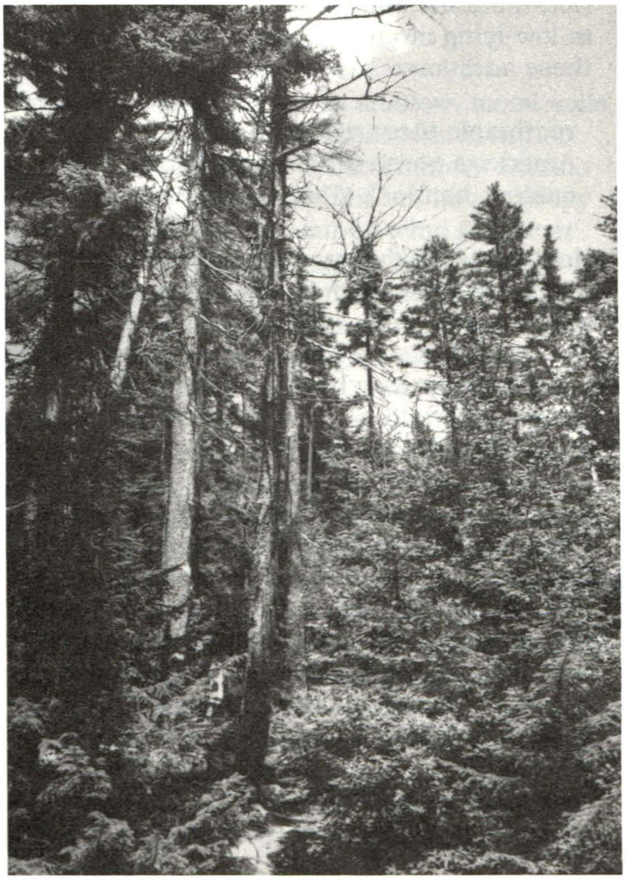
allied (mountain wetlands, lower slope, and coastal)
5 - balsam fir
30 - red spruce-yellow birch
32 - red spruce
33 - red spruce-balsam fir

The following Combined Data Systems (CDS) forest cover type for the USDA Forest Service Eastern Region (USDA 1974) is included in the montane and allied spruce-fir forest type group:

13 - red spruce/balsam fir

Species Composition

Red spruce (*Picea rubens* Sarg.) is one of the major components of montane spruce-fir forests from the northeast United States and adjacent Canada to the southern Appalachians. Low-elevation allied forest types (Burns and Honkala 1990a) are similar in composition. The fir component in the southern Appalachian spruce-fir communities is Fraser fir (*Abies fraseri* [Pursh] Poir.), which reaches its northernmost limit at Mount Rogers in southwestern Virginia (Stephenson and Adams 1984). Transitional montane stands in West Virginia contain balsam (northern) fir (*Abies balsamea* [L.] Mill.) and red spruce. Some isolated high-elevation stands in Virginia contain red spruce but no fir, perhaps due to loss of habitat in the xerothermic period (Rheinhardt and Ware 1984).



▶ *Red spruce trees at* ***Nancy Brook Research Natural Area*** *on the White Mountain National Forest in New Hampshire are more than 400 years old. See Carbonneau (1986a), Cogbill (1996), Leak (1985b). Photo 7/92 by Lucy Tyrrell.*

Red spruce, yellow birch (*Betula alleghaniensis* Britton), American mountain ash (*Sorbus americana* Marsh.), and mountain maple (*Acer spicatum* Lam.) are present in most spruce and spruce-fir forests. However, associated species differ according to location, slope position, and possibly soil depth and nutrient capacity. For example, a red spruce-balsam fir-yellow birch-beech spruce flats community type has been described by Roman (1980).

In the northern Appalachians, Adirondacks, and adjacent Canada, prominent associates in montane spruce-fir stands are:

- balsam fir
- paper birch (*Betula papyrifera* Marsh.)
- showy mountain-ash (*Sorbus decora* [Sarg.] Schneid.)
- mountain paper birch (*Betula papyrifera* var. *cordifolia* [Regel] Fern.)
- striped maple (*Acer pennsylvanicum* L.)

In the southern Appalachians, frequent associates are:

- Fraser fir
- pin cherry (*Prunus pensylvanica* L.f.)

Non-montane stands along coastal areas and in low-lying mountain wetlands may have these additional associates:

- red maple (*Acer rubrum* L.)
- American beech (*Fagus grandifolia* Ehrh.)
- eastern hemlock (*Tsuga canadensis* L.)

Hobblebush (*Viburnum alnifolium* Marsh.) and blueberry (*Vaccinium* sp. L.) are characteristic understory shrubs throughout the Appalachians and Adirondacks. Southern stands on moist aspects may have dense evergreen shrub layers, especially of rhododendron (*Rhododendron canadense* (L.) BSP).

Many herbaceous species grow in the understory of spruce and spruce-fir forests. Of particular interest are the lichens in the Caliciales group (Selva 1988). Recent research indicates that species in this group may be strongly correlated to virgin or old-growth spruce-fir stands in New England and Canada (Selva 1994).

PHYSICAL CONTEXT

Physiographic Provinces

The montane and allied spruce-fir forests occur in the following physiographic provinces (after Fenneman 1938):

Blue Ridge	(all sections)
Ridge and Valley	(Hudson, Champlain and Middle sections)
Appalachian Plateaus	(all sections except Cumberland Mountains and Cumberland Plateau)
New England	(all sections)
Adirondack	
Canadian Maritimes	(all sections)

Ecological Units

Montane and allied spruce-fir forests occur in several divisions and provinces (see Keys *et al.* 1995):

200	Humid Temperate Domain
210	Warm Continental Division
212	Laurentian Mixed Forest Province
M210	Warm Continental Regime Mountains
M212	Adirondack-New England Mixed Forest-Coniferous Forest-Alpine Meadow Province
M220	Hot Continental Regime Mountains
M221	Central Appalachian Broadleaf Forest-Coniferous Forest-Meadow Province

Geographic Distribution

Montane and allied spruce and spruce-fir forests occur at middle-to-high elevations in the Appalachians from the Canadian Maritime Provinces and Maine to North Carolina. These forests are best developed in the northern Appalachians and Adirondack Mountains. In these areas they cover most mountains down to the mid-slopes or about 750 to 1,200 m (2,500-4,000 ft) (Leak and Graber 1974). At higher elevations (Adirondack plateau) and more northerly locations (Maine), there are more extensive red spruce-balsam fir forests than in the rest of New England. Montane spruce-fir forests are absent or poorly developed in the lower mountains of the central Appalachians (Pennsylvania); however, they

▲ *Coastal fog in Acadia National Park, Maine, provides much the same moisture conditions as cloud-fog that occurs at high altitudes. Here at* ***Blackwoods****, a red spruce is measured to be 31 cm in diameter. In the right background, an uprooted tree has produced microtopography as well as dead wood. Photo 2/92 by Lucy Tyrrell.*

are common in the higher mountains of the southern Appalachians where they cap all the highest peaks (Oosting and Billings 1951).

Montane spruce-fir forests typically grow in fog-shrouded locations where direct cloud contact provides an important source of moisture. Closely allied forests include red spruce-dominated stands occurring at low elevations along the Atlantic coastline (Maine and maritime provinces) and in mountain wetlands. These mountain wetlands, or "inverted flats," are distinct from northeastern boreal bogs and peatlands. "Spruce flats" are found below deciduous forests, frequently along poorly drained stream margins. Here soils are cool and moist and cool air drains into the flats (Roman 1980, Cogbill 1987).

Soils

Montane spruce-fir forests generally grow on shallow, poorly developed, very acid (pH 3.4-5.5), coarse-textured to rocky soils underlain by granite bedrock. These thin soils are mostly Podzols and include Spodosols, Inceptisols, and sometimes Histosols. A thick mor humus is characteristic of these forests, and, where soils are developed (usually mid-slope and lower positions), a well-defined E horizon (zone of leaching) is often present (Blum 1990). At lower elevations, soils are similar, but better developed sandy-to-clay podzolic loams (Davis 1966). At higher fir-dominated elevations, stands develop on thick layers of moss and organic matter lying directly on bedrock.

DISTURBANCE

Fire

Development of old-growth red spruce-fir forests requires long periods without fire (Cogbill 1982). Natural fire intervals of 500-1,000 years in New England (Fahey and Reiners 1981) and much longer in the southern Appalachians (Harmon 1981) allow for old-growth forest development in these areas, provided the stand or seed sources are not eliminated by logging, fire, and other human activity. The lack of fire in natural old-growth red spruce-fir forests contrasts markedly with the devastating slash fires that occurred in heavily logged stands at the turn of the 19th century (Korstian 1937, Westveld 1953).

Wind

Since these forests grow in shallow, moist soils and "fog-drip" mountain areas, wind, rather than fire, is the primary disturbance. Stands dominated by red spruce tend to have canopy gaps of 15-150 m^2 created by wind (White *et al.* 1985). Such small gaps retain moister seed beds and more stable environments than do larger disturbance patches, which favor red spruce dominance in old-growth stands (Westveld 1953).

Higher elevation balsam fir-dominated forests (SAF type 05) experience more severe wind damage, often resulting in "fir wave" mortality across the montane landscape (Fitzgerald and Raynal 1991, Reiners and Lang 1979, Sprugel 1976). Because of exposure and limited rooting depth, these forests are susceptible to large-scale blowdowns during storms.

Insects

Insect outbreaks, particularly spruce budworm and the balsam woolly adelgid (Busing *et al.* 1988), can cause widespread damage. However, only when windthrow or insect attacks are coupled with extreme droughts does tree mortality predispose these areas to fire.

Spruce-fir "Decline"

Numerous researchers (Hornbeck and Smith 1985, LeBlanc 1990, Siccama 1974, Siccama *et al.* 1982) have documented red spruce decline in most montane environments, particularly at high elevations and on thin soils. Even in some productive old-growth stands, subdominant spruce are not responding to canopy mortality (Adams and Stephenson 1989). Some researchers have linked acid deposition and resulting soil chemistry changes with red spruce decline (Johnson and Siccama 1984); others have found evidence of root-feeding insects, rime ice damage, and other factors (Hertel 1987). Researchers agree that high-elevation red spruce, at least in the Northeast, is suffering high mortality from a complex of causes not related to normal competitive stressors (LeBlanc 1990).

Montane spruce-fir stands in the southern Appalachians are suffering from a different threat. Here red spruce does not appear to be declining and may even be stabilizing in many stands (Busing *et al.* 1988). However, extensive mortality caused by the exotic balsam woolly aphid (*Adelges piceae*) threatens to eliminate all mature Fraser fir within the next few decades (Bailey 1985, Beck 1990, Harmon *et al.* 1983). However, fir regenerates successfully following attack, and young trees appear fairly resistant (Bailey 1985). An isolated population of Fraser fir on Mount Rogers in southwestern Virginia may be genetically resistant to the balsam woolly adelgid (Rheinhardt and Ware 1984).

In low-elevation and coastal forests of the Northeast, red spruce is not suffering unusual mortality (Blum 1990, Burns and Honkala 1990a). In some old-growth stands in New York (McMartin 1994) and New Hampshire (Leak 1987b), red spruce has increased in importance while balsam fir and yellow birch declined. Although these allied spruce-fir types (mountain wetland, low slope, and coastal stands) have moisture conditions similar to their montane counterparts, they are not experiencing a similar decline.

RELATION TO OTHER FOREST TYPES

Montane forests differ from subboreal forests in having (1) overstories dominated by red spruce rather than white or black spruce, (2) greater diversity of vascular plant species, and (3) wind-dominated rather than fire-dominated disturbance regimes (Cogbill and White 1991). In eastern Canada, where annual precipitation falls below 87 cm and the natural fire interval drops below 100 years, red spruce gradually yields to the black and white spruces of subboreal forests.

STRUCTURAL CHARACTERISTICS OF OLD-GROWTH STANDS

Information about montane and allied spruce-fir forests in an old-growth condition is included in Figure 11 and Tables 77 through 86.

SELECTED REPRESENTATIVE OLD-GROWTH STANDS

Maine

Bald Mountain, Washington Co.

Basin Ponds, Mount Katahdin Township, Piscataquis Co.
(Maine Critical Areas Program 1983b)

Bernard Mountain, Town of Southwest Harbor, Hancock Co.

Big Lake*, Washington Co.

Big Reed Pond Preserve*, Piscataquis Co.
(Cogbill 1985, Selva 1994)

Buckle Island, Town of Swan's Island, Hancock Co.

Chandler Mountain, Aroostook Co.

Chesuncook Lake, Piscataquis Co.

Crocker Mountain, Town of Carrabassett Valley, Franklin Co.

Dry Town (T13 R11), Aroostook Co.
(Maine Critical Areas Program 1983b, Selva 1994)

East Royce Mountain, Town of Batchelder's Grant, Oxford Co.

Elephant Mountain, Franklin Co.
(Maine Critical Areas Program 1983b)

Hurd Mountain, Piscataquis Co.
(Maine Critical Areas Program 1983b)

Town of Jonesborough, Washington Co.

Moosehorn Stream, Piscataquis Co.

Mooseleuk Mountain, Piscataquis Co.
(Maine Critical Areas Program 1983b)

Nestuntabunt Mountain, Rainbow Township, Piscataquis Co.
(Maine Critical Areas Program 1983b)

North Traveler, Piscataquis Co.
(Maine Critical Areas Program 1983b)

Number 9 Mountain, Aroostook Co.
(Maine Critical Areas Program 1983b, Selva *et al.* 1988)

Priestly Mountain*, Piscataquis Co.
(Maine Critical Areas Program 1983b)

Roque Island, Town of Jonesport, Washington Co.
(Maine Critical Areas Program 1983b)

Sugarloaf Mountain-Burnt Hill Saddle, Franklin Co.
(Maine Critical Areas Program 1983b)

Traveler Mountain, Piscataquis Co.
(Maine Critical Areas Program 1983b, Selva *et al.* 1988)

Wassataquoik Lake, Piscataquis Co.
(Maine Critical Areas Program 1983b)

Wizard Pond, Hancock Co.
(Cogbill 1996)

New Hampshire

Crawford Notch*, White Mountain National Forest

Gibbs Brook Scenic Area*, White Mountain National Forest
(Carbonneau 1986a, Foster and Reiners 1983)

Nancy Brook*, White Mountain National Forest
(Carbonneau 1986a, Leak 1985b)

Norton Pool, Coos Co.
(Carbonneau 1986a, Lyon and Reiners 1971)

The Bowl Research Natural Area*, White Mountain National Forest
(Carbonneau 1986a, Leak 1985b, Leak and Graber 1974)

New York

Gill Brook*, Town of Keene, Essex Co.
(Leopold *et al.* 1988)

◀ *A remnant red spruce stand occurs at approximately 1,250 m elevation at* ***Gaudineer Scenic Area*** *on the Monongahela National Forest in West Virginia. See Adams and Stephenson (1989). Photo 7/94 by Lucy Tyrrell.*

Phelps Brook, Essex Co., Adirondack Park
(Leopold *et al.* 1988)

Whiteface Mountain
(Fitzgerald and Raynal 1991, LeBlanc 1990, Sprugel 1976)

Powley—Spruce Flat
(McMartin 1994)

North Carolina

Black Mountain Research Natural Area*, Yancey Co.
(Boner 1979, Korstian 1937)

Great Smoky Mountains National Park*
(Boner 1979, Crandall 1958, Oosting and Billings 1951, White *et al.* 1985, numerous others)

Mount Pisgah*, near Blue Ridge Parkway

Powley—Mixed
(McMartin 1994)

Totten & Crossfield Township 40*
(Hosmer and Bruce 1901)

Tennessee

Great Smoky Mountains National Park*
(Boner 1979, Crandall 1958, Oosting and Billings 1951, White *et al.* 1985, numerous others)

Roan High Bluff (northwest side)

Vermont

Camels Hump State Forest
(Siccama 1974, Siccama *et al.* 1982)

East Mountain-East Haven, Essex Co.

Hunger Mountain, Washington Co.

West Virginia

Gaudineer Scenic Area*, Monongahela National Forest
(Adams and Stephenson 1989)

Shaver's Mountain Spruce-Hemlock Stand, Monongahela National Forest
(Adams and Stephenson 1989)

FOR ADDITIONAL INFORMATION

Additional references that pertain to montane and allied spruce-fir forests but are not cited in tables or text are listed by forest type group in Appendix C.

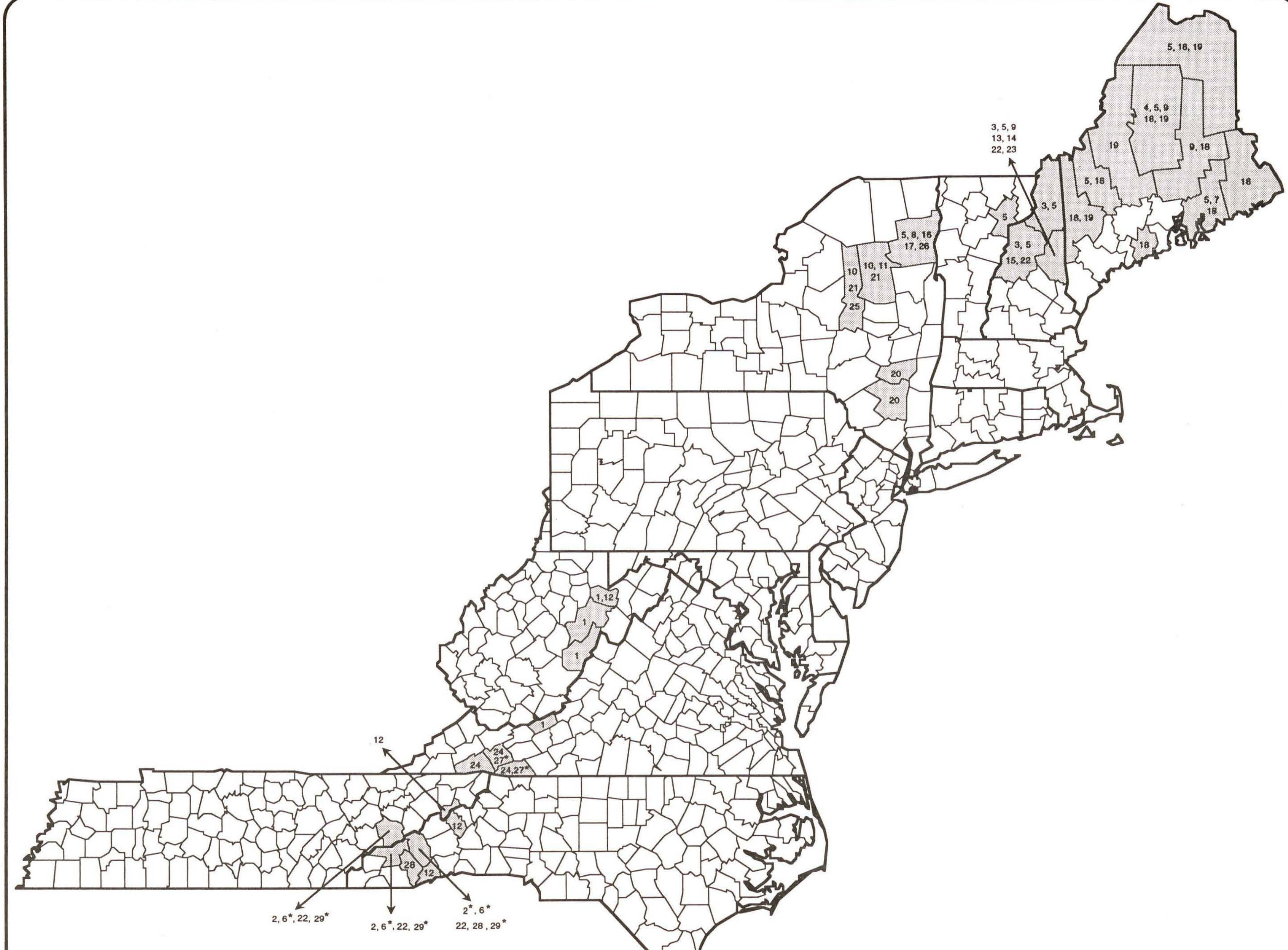

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Figure 11.—*General location of studies that provide stand structure information about old-growth montane and allied spruce-fir forests. Shaded counties contain at least one study. Numbers correspond to the cited references listed under Map Key below and in Tables 77 through 86. States are indicated using two-letter postal abbreviations. An asterisk indicates that the county is probable, but not certain.*

Map Key	Source/Date	State or Province	County
1	Adams and Stephenson 1989	WV	Pocahontas, Randolph, Tucker
		VA	Giles
2	Boner 1979	NC	Haywood*, Swain
		TN	Sevier
3	Carbonneau 1986a	NH	Carroll, Coos, Grafton
4	Cogbill 1985	ME	Piscataquis
5	Cogbill 1996	ME	Aroostook, Franklin, Hancock, Piscataquis, Penobscot
		NH	Carroll, Coos, Grafton
		NY	Essex
		VT	Caledonia
6	Crandall 1958	NC	Haywood, Swain
		TN	Sevier
7	Davis 1966	ME	Hancock
8	Fitzgerald and Raynal 1991	NY	Essex
9	Foster and Reiners 1983	ME	Penobscot, Piscataquis
		NH	Carroll
10	Graves 1899	NY	Hamilton, Herkimer
11	Hosmer and Bruce 1901	NY	Hamilton
12	Korstian 1937	NC	Transylvania, Yancey
		TN	Unicoi
		WV	Tucker
13	Leak 1985b	NH	Carroll
14	Leak 1987b	NH	Carroll
15	Leak and Graber 1974	NH	Grafton
16	LeBlanc 1990	NY	Essex
17	Leopold et al. 1988	NY	Essex
18	Maine Critical Areas Program 1983b	ME	Aroostook, Franklin, Hancock, Lincoln, Oxford, Penobscot, Piscataquis, Washington
19	Maine State Planning Office 1986	ME	Aroostook, Oxford, Piscataquis, Somerset
20	McIntosh and Hurley 1964	NY	Greene, Ulster
21	McMartin 1994	NY	Hamilton
22	Oosting and Billings 1951	NC	Haywood, Swain
		NH	Carroll, Grafton
		TN	Sevier
23	Reiners and Lang 1979	NH	Carroll
24	Rheinhardt and Ware 1984	VA	Grayson, Smythe, Washington
25	Roman 1980	NY	Herkimer
26	Sprugel 1976	NY	Essex
27	Stephenson and Adams 1984	VA	Grayson, Smythe
28	Weaver 1972	NC	Haywood, Jackson
29	White et al. 1985	NC	Haywood*, Swain*
		TN	Sevier*

Table 77.—*Location, size, and elevation of montane and allied spruce-fir old-growth study sites.*

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
1	Adams and Stephenson 1989	Gaudineer Knob	WV	Pocahontas	50	1200
1	Adams and Stephenson 1989	Salt Pond Mountain	VA	Giles	>1, <50	1110
1	Adams and Stephenson 1989	Shavers Mountain	WV	Randolph	>1, <50	1130
1	Adams and Stephenson 1989	Turkey Run	WV	Tucker	>1, <50	1112
2	Boner 1979	Great Smoky Mountains--<1830m	NC,TN	Haywood*, Swain (NC), Sevier (TN)	unspecified	<1830
2	Boner 1979	Great Smoky Mountains--≥1830m	NC,TN	Haywood*, Swain (NC), Sevier (TN)	unspecified	≥1830
3	Carbonneau 1986a	Eagle Cliff--SF-3	NH	Grafton	6	610-730
3	Carbonneau 1986a	Gibbs Brook--SF-2	NH	Carroll	360	700-1310
3	Carbonneau 1986a	Nancy Brook--SF-1	NH	Carroll	400	855-1190
3	Carbonneau 1986a	Norton Pool--SF-4	NH	Coos	50	580-610
4	Cogbill 1985	Big Reed Pond--Red Spruce-Fir	ME	Piscataquis	879	335-430
4	Cogbill 1985	Big Reed Pond--Red Spruce-Mixed	ME	Piscataquis	651	335-430
5	Cogbill 1996	Basin Ponds	ME	Piscataquis	unspecified	805[1]
5	Cogbill 1996	Bernard Mountain	ME	Hancock	unspecified	850[1]
5	Cogbill 1996	Big Reed	ME	Piscataquis	unspecified	415[1]
5	Cogbill 1996	Dry Town	ME	Aroostook	unspecified	418[1]
5	Cogbill 1996	East Mountain	VT	Caledonia	unspecified	1024[1]
5	Cogbill 1996	Elephant Mountain	ME	Franklin	unspecified	910[1]
5	Cogbill 1996	Gill Brook	NY	Essex	unspecified	1000[1]
5	Cogbill 1996	Lake Arnold	NY	Essex	unspecified	1170[1]
5	Cogbill 1996	Nancy Brook	NH	Carroll	unspecified	unspecified
5	Cogbill 1996	North Turner Brook	ME	Piscataquis	unspecified	628[1]
5	Cogbill 1996	Norton Pool	NH	Coos	unspecified	595[1]
5	Cogbill 1996	Phelps Mountain	NY	Essex	unspecified	927[1]
5	Cogbill 1996	The Bowl	NH	Grafton	unspecified	unspecified
5	Cogbill 1996	Wizard Pond	ME	Hancock	unspecified	250[1]
6	Crandall 1958	Great Smoky Mountains (GSM)	NC, TN	Haywood, Swain (NC), Sevier (TN)	unspecified	1465-1980
6	Crandall 1958	GSM--Fir Type-O-H T[2]	NC, TN	Haywood*, Swain* (NC), Sevier* (TN)	unspecified	1920-1980
6	Crandall 1958	GSM--Fir Type-O-D T[2]	NC, TN	Haywood*, Swain* (NC), Sevier* (TN)	unspecified	1920-1980
6	Crandall 1958	GSM--Fir Type-Vi-Va-D T[2]	NC, TN	Haywood*, Swain* (NC), Sevier* (TN)	unspecified	1890-1950
6	Crandall 1958	GSM--Fir Type-Se T[2]	NC, TN	Haywood*, Swain* (NC), Sevier* (TN)	unspecified	1920-1980
6	Crandall 1958	GSM--Spruce-Fir Type-O-H T[2]	NC, TN	Haywood*, Swain* (NC), Sevier* (TN)	unspecified	1700-1830
6	Crandall 1958	GSM--Spruce-Fir Type-H-Va T[2]	NC, TN	Haywood*, Swain* (NC), Sevier* (TN)	unspecified	1890-1950
6	Crandall 1958	GSM--Spruce-Fir Type-Vi-Va-D T[2]	NC, TN	Haywood*, Swain* (NC), Sevier* (TN)	unspecified	1675-1800
6	Crandall 1958	GSM--Spruce-Fir Type-Vi-Va-Se T[2]	NC, TN	Haywood*, Swain* (NC), Sevier* (TN)	unspecified	1700-1920
6	Crandall 1958	GSM--Spruce-Fir Type-R T[2]	NC, TN	Haywood*, Swain* (NC), Sevier* (TN)	unspecified	1675-1700
6	Crandall 1958	GSM--Spruce-Fir Type-R (Vi) T[2]	NC, TN	Haywood*, Swain* (NC), Sevier* (TN)	unspecified	1700
6	Crandall 1958	GSM--Spruce Type-H-Va T[2]	NC, TN	Haywood*, Swain* (NC), Sevier* (TN)	unspecified	1770
6	Crandall 1958	GSM--Spruce Type-Vi-Va-D T[2]	NC, TN	Haywood*, Swain* (NC), Sevier* (TN)	unspecified	1650-1800
6	Crandall 1958	GSM--Spruce Type-Vi-Va-L T[2]	NC, TN	Haywood*, Swain* (NC), Sevier* (TN)	unspecified	1550-1170

(Table 77 continued on next page)

(Table 77 continued)

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
6	Crandall 1958	GSM--Spruce Type-R T[2]	NC, TN	Haywood*, Swain* (NC), Sevier* (TN)	unspecified	1550-1620
6	Crandall 1958	GSM--Spruce Type-R (Vi) T[2]	NC, TN	Haywood*, Swain* (NC), Sevier* (TN)	unspecified	1550-1830
6	Crandall 1958	GSM--Spruce-Hardwood Type-Vi T[2]	NC, TN	Haywood*, Swain* (NC), Sevier* (TN)	unspecified	1555-1650
6	Crandall 1958	GSM--Spruce-Hardwood Type-As T[2]	NC, TN	Haywood*, Swain* (NC), Sevier* (TN)	unspecified	1465-1525
6	Crandall 1958	GSM--Spruce-Hardwood Type-R T[2]	NC, TN	Haywood*, Swain* (NC), Sevier* (TN)	unspecified	1525
7	Davis 1966	Ironbound Island	ME	Hancock	>2	<500
7	Davis 1966	Otter Point	ME	Hancock	>2	<500
7	Davis 1966	Western Mountain	ME	Hancock	>2	<500
8	Fitzgerald and Raynal 1991	Whiteface Mountain--900 m	NY	Essex	1.5	900
8	Fitzgerald and Raynal 1991	Whiteface Mountain--1100 m	NY	Essex	1.5	1100
9	Foster and Reiners 1983	Basin Ponds	ME	Piscataquis	unspecified	823
9	Foster and Reiners 1983	Bernard Mountain	ME	Piscataquis	unspecified	305
9	Foster and Reiners 1983	Gibbs Brook--825 m	NH	Carroll	} 667[3]	825
9	Foster and Reiners 1983	Gibbs Brook--890 m	NH	Carroll	}	890
9	Foster and Reiners 1983	Gibbs Brook--955 m	NH	Carroll	}	955
9	Foster and Reiners 1983	Gibbs Brook--1020 m	NH	Carroll	}	1020
9	Foster and Reiners 1983	North Traveler Mountain	ME	Penobscot	unspecified	738
10	Graves 1899	Nehasane Park--spruce flats	NY	Hamilton, Herkimer	}16,000+[4]	}520-610[5]
10	Graves 1899	Nehasane Park--spruce slopes	NY	Hamilton, Herkimer	}	}
10	Graves 1899	Nehasane Park--swamp lands	NY	Hamilton, Herkimer	}	}
11	Hosmer and Bruce 1901	Township 40--spruce lower slopes	NY	Hamilton	6040	540- 732
11	Hosmer and Bruce 1901	Township 40--swamp	NY	Hamilton	800	540- 732
11	Hosmer and Bruce 1901	Township 40--upper spruce slopes	NY	Hamilton	15+	>732
12	Korstian 1937	Black Mountains	NC	Yancey	unspecified	1585
12	Korstian 1937	Pisgah Ridge	NC	Transylvania	unspecified	unspecified
12	Korstian 1937	Turkey Run	WV	Tucker	unspecified	unspecified
12	Korstian 1937	Unaka Mountain	TN	Unicoi	unspecified	unspecified
13	Leak 1985b	Nancy Brook	NH	Carroll	~120	885
13	Leak 1985b	The Bowl	NH	Carroll	16+	600
14	Leak 1987b	Bartlett--Bedrock-500-550 m-1932	NH	Carroll	} 1050[6]	500-550
14	Leak 1987b	Bartlett--Bedrock-500-550 m-1984	NH	Carroll	}	500-550
14	Leak 1987b	Bartlett--Bedrock-650 m-1932	NH	Carroll	}	650
14	Leak 1987b	Bartlett--Bedrock-650 m-1984	NH	Carroll	}	650
15	Leak and Graber 1974	Mt. Whiteface/The Bowl	NH	Grafton	mountainside	700-1200
16	LeBlanc 1990	Whiteface Mountain	NY	Essex	unspecified	900, 1100
17	Leopold et al. 1988	Phelps Brook	NY	Essex	80	980
18	Maine Critical Areas Program 1983b	Basin Ponds	ME	Piscataquis	1.6	793-854
18	Maine Critical Areas Program 1983b	Bernard Mountain	ME	Hancock	8	213-320
18	Maine Critical Areas Program 1983b	Cathedral Woods	ME	Lincoln	4	~40
18	Maine Critical Areas Program 1983b	Crocker Mountain	ME	Franklin	unspecified	1000-1220

(Table 77 continued on next page)

(Table 77 continued)

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
18	Maine Critical Areas Program 1983b	East Royce Mountain	ME	Oxford	1.6	793-823
18	Maine Critical Areas Program 1983b	Elephant Mountain	ME	Franklin	unspecified	878-915
18	Maine Critical Areas Program 1983b	Hurd Mountain	ME	Piscataquis	6	300
18	Maine Critical Areas Program 1983b	Jonesborough	ME	Washington	12	30
18	Maine Critical Areas Program 1983b	Mooseleuk Mountain	ME	Piscataquis	16	457-610
18	Maine Critical Areas Program 1983b	Nestuntabunt Mountain	ME	Piscataquis	4	290
18	Maine Critical Areas Program 1983b	North Traveler	ME	Penobscot	10	610-747
18	Maine Critical Areas Program 1983b	No. 9 Mountain	ME	Aroostook	12	427
18	Maine Critical Areas Program 1983b	Priestly Mountain	ME	Piscataquis	<2	457
18	Maine Critical Areas Program 1983b	Roque Island	ME	Washington	12	<12
18	Maine Critical Areas Program 1983b	Sugarloaf-Burnt Hill Saddle	ME	Franklin	unspecified	976
18	Maine Critical Areas Program 1983b	T13 R11 Red Spruce	ME	Aroostook	37	427+
18	Maine Critical Areas Program 1983b	Traveler Mountain	ME	Piscataquis	2.4	730-790
18	Maine Critical Areas Program 1983b	Wassataquoik Lake	ME	Piscataquis	8	580
19	Maine State Planning Office 1986	Black Mountain	ME	Aroostook	53	400-580
19	Maine State Planning Office 1986	Center Mountain	ME	Piscataquis	1	845
19	Maine State Planning Office 1986	Crater-Denny-Galilee	ME	Aroostook	57	355-550
19	Maine State Planning Office 1986	Deboullie Mountain	ME	Aroostook	30	365-600
19	Maine State Planning Office 1986	East Nubble Red Spruce [7]	ME	Somerset	11	640-745
19	Maine State Planning Office 1986	Gardner Mountain	ME	Aroostook	86	345-550
19	Maine State Planning Office 1986	Mahoosuc Mountain [7]	ME	Oxford	4.5	1045
19	Maine State Planning Office 1986	Pushineer Pond	ME	Aroostook	20	345-490
19	Maine State Planning Office 1986	Wassataquiok Mountain	ME	Piscataquis	10	580-730
20	McIntosh and Hurley 1964	Catskills--22 stands	NY	Ulster, Greene	unspecified	1040-1130
21	McMartin 1994	Big Moose Lake	NY	Hamilton	unspecified	unspecified
21	McMartin 1994	Powley--Red Spruce/Mixed Stand	NY	Hamilton	1000+	unspecified
21	McMartin 1994	Powley--Spruce Flat	NY	Hamilton	350-400	unspecified
21	McMartin 1994	Stillwater Reservoir	NY	Herkimer	unspecified	unspecified
22	Oosting and Billings 1951	Great Smoky Mountains (9 stands)	NC, TN	Haywood, Swain (NC), Sevier (TN)	unspecified	1700-1970
22	Oosting and Billings 1951	White Mountains (4 stands)	NH	Grafton, Carroll	unspecified	760-840
23	Reiners and Lang 1979	Three areas in White Mountains [8]	NH	Carroll	unspecified	1220-tree line
24	Rheinhardt and Ware 1984	Balsam Mountains--Spruce-Fir	VA	Grayson, Smythe, Washington	} 14,000 [9]	1591-1739
24	Rheinhardt and Ware 1984	Balsam Mountains--Spruce	VA	Grayson, Smythe, Washington	}	1463-1609
25	Roman 1980	Adirondacks--Poor Fen	NY	Herkimer	} 24,000 [10]	unspecified
25	Roman 1980	Adirondacks--Rich Fen	NY	Herkimer	}	unspecified
25	Roman 1980	Adirondacks--Upland Mixed-red spruce	NY	Herkimer	}	unspecified
26	Sprugel 1976	Whiteface Mountain--Esther/Lookout	NY	Essex	unspecified	~1250
27	Stephenson and Adams 1984	Mount Rogers--5 stands near summit	VA	Grayson, Smythe	} <250 [11]	1707-1738
27	Stephenson and Adams 1984	Mount Rogers--NE Slope	VA	Grayson*, Smythe*	}	1723
27	Stephenson and Adams 1984	Mount Rogers--NW Slope	VA	Smythe	}	1733

(Table 77 continued on next page)

(Table 77 continued)

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
27	Stephenson and Adams 1984	Mount Rogers--Ridgetop	VA	Grayson*, Smythe*	}	1738
27	Stephenson and Adams 1984	Mount Rogers--SE Slope	VA	Grayson	}	1730
27	Stephenson and Adams 1984	Mount Rogers--SW Slope	VA	Grayson	}	1707
28	Weaver 1972	Balsam Mountains	NC	Haywood, Jackson	mtn crest	1570-1945
29	White et al. 1985	Great Smoky Mountains--Mt. Collins	NC, TN	Haywood*, Swain* (NC), Sevier* (TN)	7	1750-1800

[1] Evaluation from Cogbill, personal communication.

[2] GSM = Great Smoky Mountains. Explanation of community types is as follows:

O-H T - Oxalis-Hylocomium Type
O-D T - Oxalis-Dryopteris Type
Vi-Va-D T - Viburnum-Vaccinium-Dryopteris Type
Se T - Senecio Type
O-H T - Oxalis-Hylocomium Type
H-Va T - Hylocomium-Vaccinium Type
Vi-Va-D T - Viburnum-Vaccinium-Dryopteris Type
Vi-Va-Se T - Viburnum-Vaccinium-Senecio Type
R T - Rhododendron Type
R (Vi) T - Rhododendron (Viburnum) Type
H-Va T - Hylocomium-Vaccinium Type
Vi-Va-D T - Viburnum-Vaccinium-Dryopteris Type
Va-Va-L T - Viburnum-Vaccinium-Lycopodium Type
R T - Rhododendron Type
R (Vi) T - Rhododendron (Viburnum) Type
Vi T - Viburnum Type
As T - Aster Type
R T - Rhododendron Type

[3] Area of entire Crawford Notch area.

[4] Area of entire Nehasane Park.

[5] Elevation range for Nehasane Park.

[6] Area for entire Bartlett Experimental Forest.

[7] See also Hudson et al. (1986).

[8] Mt. Moosilauke, Presidential Range, Carter Range.

[9] Old-growth area covers 70% of Balsam Mountains study area of 20,000 ha.

[10] Size of the Five Ponds Wilderness Area.

[11] Area is area for spruce and/or fir on Mount Rogers.

Table 78.—*Criteria used by sources to identify old-growth stands, and information about stand composition of montane and allied spruce-fir old-growth study sites.*

Map Key	Source/Date	Stand	Criteria for Stand Selection and Stand Composition
1	Adams and Stephenson 1989	Gaudineer Knob	Old growth > 160 yr; undisturbed; red spruce (38%)-yellow birch (22%)-beech (17%)
1	Adams and Stephenson 1989	Salt Pond Mountain	Old growth >160 yr; undisturbed; hemlock (49%)-red spruce (21%)-yellow birch (19%)
1	Adams and Stephenson 1989	Shavers Mountain	Old growth >160 yr; undisturbed; hemlock (45%)-red spruce (34%)-yellow birch (22%)
1	Adams and Stephenson 1989	Turkey Run	Old growth >160 yr; undisturbed; red spruce (70%)-yellow birch (14%)
2	Boner 1979	Great Smoky Mountains--<1830m	Old growth, undisturbed by adelgid; red spruce (51%)-Fraser fir (36%)
2	Boner 1979	Great Smoky Mountains-->=1830m	Old growth, undisturbed by adelgid; Fraser fir (68%)-red spruce (29%)
3	Carbonneau 1986a	Eagle Cliff--SF-3	Virgin; old growth >150 yr; spruce-yellow birch-balsam fir
3	Carbonneau 1986a	Gibbs Brook--SF-2	Virgin; old growth >150 yr; spruce-balsam fir
3	Carbonneau 1986a	Nancy Brook--SF-1	Virgin; old growth >150 yr; spruce
3	Carbonneau 1986a	Norton Pool--SF-4	Virgin; old growth >150 yr; spruce-balsam fir
4	Cogbill 1985	Big Reed Pond--Red Spruce-Fir	Old growth; most uncut [1]; spruce (62%)-cedar (14%)
4	Cogbill 1985	Big Reed Pond--Red Spruce-Mixed	Old growth; most uncut; spruce (36%)-sugar maple (27%)-beech (13%)
5	Cogbill 1996	Basin Ponds	Old-growth spruce stand; spruce
5	Cogbill 1996	Bernard Mountain	Old-growth spruce stand; spruce
5	Cogbill 1996	Big Reed	Old-growth spruce stand; spruce
5	Cogbill 1996	Dry Town	Old-growth spruce stand; spruce
5	Cogbill 1996	East Mountain	Old-growth spruce stand; fir
5	Cogbill 1996	Elephant Mountain	Old-growth spruce stand; fir-spruce
5	Cogbill 1996	Gill Brook	Old-growth spruce stand; spruce-fir
5	Cogbill 1996	Lake Arnold	Old-growth spruce stand; fir
5	Cogbill 1996	Nancy Brook	Old-growth spruce stand; spruce-fir
5	Cogbill 1996	North Turner Brook	Old-growth spruce stand; spruce
5	Cogbill 1996	Norton Pool	Old-growth spruce stand; spruce-fir
5	Cogbill 1996	Phelps Mountain	Old-growth spruce stand; spruce-fir
5	Cogbill 1996	The Bowl	Old-growth spruce stand; spruce-birch
5	Cogbill 1996	Wizard Pond	Old-growth spruce stand; spruce
6	Crandall 1958	Great Smoky Mountains (GSM)	Accessible regions of GSMNP [2]--spruce, fir, spruce-fir, and spruce-hardwoods [3]
6	Crandall 1958	GSM--Fir Type-O-H T [4]	Accessible regions of GSMNP; Fraser fir (86%)-red spruce (14%)
6	Crandall 1958	GSM--Fir Type-O-D T	Accessible regions of GSMNP; Fraser fir (82%)-red spruce (17%)
6	Crandall 1958	GSM--Fir Type-Vi-Va-D T	Accessible regions of GSMNP; Fraser fir (63%)-red spruce (33%)
6	Crandall 1958	GSM--Fir Type-Se T	Accessible regions of GSMNP; Fraser fir (84%)-red spruce (16%)
6	Crandall 1958	GSM--Spruce-Fir Type-O-H T	Accessible regions of GSMNP; red spruce (74%)-yellow birch (14%)-Fraser fir (12%)
6	Crandall 1958	GSM--Spruce-Fir Type-H-Va T	Accessible regions of GSMNP; red spruce (60%)-Fraser fir (41%)
6	Crandall 1958	GSM--Spruce-Fir Type-Vi-Va-D T	Accessible regions of GSMNP; red spruce (58%)-Fraser fir (31%)
6	Crandall 1958	GSM--Spruce-Fir Type-Vi-Va-Se T	Accessible regions of GSMNP; red spruce (60%)-Fraser fir (21%)
6	Crandall 1958	GSM--Spruce-Fir Type-R T	Accessible regions of GSMNP; red spruce (74%)-Fraser fir (26%)
6	Crandall 1958	GSM--Spruce-Fir Type-R (Vi) T	Accessible regions of GSMNP; red spruce (65%)-yellow birch (19%)-Fraser fir (15%)
6	Crandall 1958	GSM--Spruce Type-H-Va T	Accessible regions of GSMNP; red spruce (87%)-Fraser fir (9%)
6	Crandall 1958	GSM--Spruce Type-Vi-Va-D T	Accessible regions of GSMNP; red spruce (81%)-Fraser fir (13%)
6	Crandall 1958	GSM--Spruce Type-Vi-Va-L T	Accessible regions of GSMNP; red spruce (94%)-Fraser fir (5%)

(Table 78 continued on next page)

(Table 78 continued)

Map Key	Source/Date	Stand	Criteria for Stand Selection and Stand Composition
6	Crandall 1958	GSM--Spruce Type-R T	Accessible regions of GSMNP; red spruce (82%)-Fraser fir (16%)
6	Crandall 1958	GSM--Spruce Type-R (Vi) T	Accessible regions of GSMNP; red spruce (72%)-Fraser fir (27%)
6	Crandall 1958	GSM--Spruce-Hardwood Type-Vi T	Accessible regions of GSMNP; yellow birch (51%)-red spruce (28%)-Fraser fir (16%)
6	Crandall 1958	GSM--Spruce-Hardwood Type-As T	Accessible regions of GSMNP; red spruce (62%)-silverbell (10%)
6	Crandall 1958	GSM--Spruce-Hardwood Type-R T	Accessible regions of GSMNP; red spruce (41%)-yellow birch (40%)-beech (10%)
7	Davis 1966	Ironbound Island	Uncut; coastal spruce-fir
7	Davis 1966	Otter Point	No cutting known; coastal spruce-fir
7	Davis 1966	Western Mountain	Virgin; undisturbed; coastal spruce-fir
8	Fitzgerald and Raynal 1991	Whiteface Mountain--900 m	Never logged; no fires; red spruce-balsam fir
8	Fitzgerald and Raynal 1991	Whiteface Mountain--1100 m	Never logged; no fires; red spruce-balsam fir
9	Foster and Reiners 1983	Basin Ponds	Uncut; spruce-fir
9	Foster and Reiners 1983	Bernard Mountain	Uncut; spruce-fir
9	Foster and Reiners 1983	Gibbs Brook--825 m	Virgin, subalpine forest; red spruce (37%)-balsam fir (31%)-yellow birch (25%)
9	Foster and Reiners 1983	Gibbs Brook--890 m	Virgin, subalpine forest; red spruce (68%)-balsam fir (28%)
9	Foster and Reiners 1983	Gibbs Brook--955 m	Virgin, subalpine forest; balsam fir (81%)-red spruce (17%)
9	Foster and Reiners 1983	Gibbs Brook--1020 m	Virgin, subalpine forest; balsam fir (59%)-red spruce (22%)-white birch (20%)
9	Foster and Reiners 1983	North Traveler Mountain	Uncut; spruce-fir
10	Graves 1899	Nehasane Park--spruce flats	Original forest; red spruce (45%)-yellow birch (20%)-balsam fir (9%)
10	Graves 1899	Nehasane Park--spruce slopes	Original forest; red spruce (48%)-yellow birch (20%)-beech (10%)-balsam fir (5%)
10	Graves 1899	Nehasane Park--swamp lands	Original forest; red spruce (48%)-yellow birch (18%)-balsam fir (13%)
11	Hosmer and Bruce 1901	Township 40--spruce lower slopes	Virgin; spruce (46%)-yellow birch (17%)-balsam fir (9%)
11	Hosmer and Bruce 1901	Township 40--swamp	Virgin; spruce (red and black) (40%)-balsam fir (26%)-white-cedar (16%)-fir (26%)
11	Hosmer and Bruce 1901	Township 40--upper spruce slopes	Virgin; red spruce (62%)-yellow birch (18%)
12	Korstian 1937	Black Mountains	Virgin, unburned; red spruce (70%)-yellow birch (18%)-Fraser fir (12%)
12	Korstian 1937	Pisgah Ridge	Virgin, unburned; red spruce (38%)-Fraser fir (30%)-yellow birch (25%)
12	Korstian 1937	Turkey Run	Virgin, unburned; red spruce (95%)-hemlock-hardwoods
12	Korstian 1937	Unaka Mountain	Virgin, unburned; red spruce (91%)-hardwoods
13	Leak 1985b	Nancy Brook	Virgin; spruce-fir
13	Leak 1985b	The Bowl	Virgin; northern hardwoods with component of red spruce
14	Leak 1987b	Bartlett--Bedrock-500-550 m-1932	Undisturbed or very lightly cut <1890-1900; red spruce-white birch-red maple
14	Leak 1987b	Bartlett--Bedrock-500-550 m-1984	Undisturbed or very lightly cut <1890-1900; red spruce-hemlock-red maple
14	Leak 1987b	Bartlett--Bedrock-650 m-1932	Undisturbed or very lightly cut <1890-1900; red spruce-white birch-red maple
14	Leak 1987b	Bartlett--Bedrock-650 m-1984	Undisturbed or very lightly cut <1890-1900; red spruce-red maple
15	Leak and Graber 1974	Mt. Whiteface/The Bowl	Never logged; spruce-fir portion of elevational gradient
16	LeBlanc 1990	Whiteface Mountain	Virgin with > 70% red spruce mortality
17	Leopold et al. 1988	Phelps Brook	Old growth based on criteria; balsam fir (67%)-red spruce (19%)
18	Maine Critical Areas Program 1983b	Basin Ponds	Old growth; undisturbed; red spruce-balsam fir
18	Maine Critical Areas Program 1983b	Bernard Mountain	Old growth; uncut, fire origin; red spruce (85%)-yellow birch-red maple-fir
18	Maine Critical Areas Program 1983b	Cathedral Woods	Old growth; established in old field; red spruce
18	Maine Critical Areas Program 1983b	Crocker Mountain	Old growth; unlogged, undisturbed; red spruce-balsam fir

(Table 78 continued on next page)

(Table 78 continued)

Map Key	Source/Date	Stand	Criteria for Stand Selection and Stand Composition
18	Maine Critical Areas Program 1983b	East Royce Mountain	Old growth; uncut, undisturbed; red spruce-balsam fir
18	Maine Critical Areas Program 1983b	Elephant Mountain	Old growth; red spruce-balsam fir
18	Maine Critical Areas Program 1983b	Hurd Mountain	Old growth; scattered stumps; red spruce
18	Maine Critical Areas Program 1983b	Jonesborough	Old growth; no cutting last 70 yr; red spruce-white pine-white birch
18	Maine Critical Areas Program 1983b	Mooseleuk Mountain	Old growth; uncut; red spruce-balsam fir
18	Maine Critical Areas Program 1983b	Nestuntabunt Mountain	Old growth; red spruce-white pine
18	Maine Critical Areas Program 1983b	North Traveler	Old growth; uncut, probable fire origin; red spruce (87%)-balsam fir (9%)
18	Maine Critical Areas Program 1983b	No. 9 Mountain	No signs of cutting; red spruce-balsam fir-white birch
18	Maine Critical Areas Program 1983b	Priestly Mountain	Old growth; red spruce-balsam fir
18	Maine Critical Areas Program 1983b	Roque Island	Old growth; no cutting > 1827; red spruce-balsam fir
18	Maine Critical Areas Program 1983b	Sugarloaf-Burnt Hill Saddle	Old growth; uncut, virgin; red spruce
18	Maine Critical Areas Program 1983b	T13 R11 Red Spruce	Undisturbed old growth; red spruce-balsam fir
18	Maine Critical Areas Program 1983b	Traveler Mountain	Old growth; never cut; red spruce-balsam fir
18	Maine Critical Areas Program 1983b	Wassataquoik Lake	Uncut; red spruce-balsam fir
19	Maine State Planning Office 1986	Black Mountain	Uncut; red spruce
19	Maine State Planning Office 1986	Center Mountain	Uncut; red spruce
19	Maine State Planning Office 1986	Crater-Denny-Galilee	Uncut; red spruce
19	Maine State Planning Office 1986	Deboullie Mountain	Uncut; red spruce
19	Maine State Planning Office 1986	East Nubble Red Spruce	Uncut; red spruce
19	Maine State Planning Office 1986	Gardner Mountain	Uncut; red spruce
19	Maine State Planning Office 1986	Mahoosuc Mountain	Uncut; red spruce
19	Maine State Planning Office 1986	Pushineer Pond	Uncut; red spruce
19	Maine State Planning Office 1986	Wassataquiok Mountain	Uncut; red spruce
20	McIntosh and Hurley 1964	Catskills--22 stands	Two stands were considered old growth; virgin; never logged; red spruce (72%)-balsam fir (28%)
21	McMartin 1994	Big Moose Lake	Virgin
21	McMartin 1994	Powley--Red Spruce/Mixed Stand	Virgin; no logging; red spruce (45%)-yellow birch-hemlock
21	McMartin 1994	Powley--Spruce Flat	Virgin; no logging; red spruce (65%) in sphagnum wetlands
21	McMartin 1994	Stillwater Reservoir	Virgin
22	Oosting and Billings 1951	Great Smoky Mountains (9 stands)	Virgin; red spruce (53%)-fir (34%)
22	Oosting and Billings 1951	White Mountains (4 stands)	Undisturbed; red spruce (81%)-balsam fir (12%)
23	Reiners and Lang 1979	Three areas in White Mountains	Uncut and undisturbed; balsam fir zone at higher elevation than spruce-fir
24	Rheinhardt and Ware 1984	Balsam Mountains--Spruce	Old growth; never logged; red spruce (73%)-yellow birch (15%)
24	Rheinhardt and Ware 1984	Balsam Mountains--Spruce-Fir	Old growth; never logged; Fraser fir (60%)-red spruce (19%)-yellow birch (15%)
25	Roman 1980	Adirondacks--Poor Fen	Virgin; uncut; "poor fen"; black spruce (54%)-red spruce (34%)-balsam fir (3%)
25	Roman 1980	Adirondacks--Rich Fen	Virgin; uncut; "rich fen"; red spruce (80%)-balsam fir (19%)
25	Roman 1980	Adirondacks--Upland Mixed-red spruce	Virgin; uncut; red spruce (53%)-sugar maple (14%)-yellow birch (11%)- beech (7%)
26	Sprugel 1976	Whiteface Mountain--Esther/Lookout	Undisturbed except fir "waves"; balsam fir (99%)-mountain paper birch
27	Stephenson and Adams 1984	Mount Rogers--5 stands near summit	Older, without excessive windfall; Fraser fir (75%)-red spruce (22%)
27	Stephenson and Adams 1984	Mount Rogers--NE Slope	Older, without excessive windfall
27	Stephenson and Adams 1984	Mount Rogers--NW Slope	Older, without excessive windfall

(Table 78 continued on next page)

(Table 78 continued)

Map Key	Source/Date	Stand	Criteria for Stand Selection and Stand Composition
27	Stephenson and Adams 1984	Mount Rogers--Ridgetop	Older, without excessive windfall
27	Stephenson and Adams 1984	Mount Rogers--SE Slope	Older, without excessive windfall
27	Stephenson and Adams 1984	Mount Rogers--SW Slope	Older, without excessive windfall
28	Weaver 1972	Balsam Mountains	Undisturbed; fir (72%)-red spruce (27%)
29	White et al. 1985	Great Smoky Mountains--Mt. Collins	Old growth; mid-elevation distribution of Fraser fir (56%)-red spruce (30%)-yellow birch

[1] Heavy spruce budworm defoliation about 1910; some fire history.

[2] GSMNP Great Smoky Mountains National Park.

[3] Red spruce averaged over 80% of canopy basal area across a wide elevation range.

[4] For explanation of community types see Table 77, Endnote 2.

Table 79.—*Methods used to study old-growth montane and allied spruce-fir (condensed from the cited references).*

Map Key	Source/Date	Stand	Sampling Methods
1	Adams and Stephenson 1989	Gaudineer Knob	1 20 m x 50 m quadrat in 2 stands; 12+ spruce cores
1	Adams and Stephenson 1989	Salt Pond Mountain	1 20 m x 50 m quadrat in 2 stands; 12+ spruce cores
1	Adams and Stephenson 1989	Shavers Mountain	1 20 m x 50 m quadrat in 2 stands; 12+ spruce cores
1	Adams and Stephenson 1989	Turkey Run	1 20 m x 50 m quadrat in 2 stands; 12+ spruce cores
2	Boner 1979	Great Smoky Mountains--<1830m	Circular 0.04-ha plots in 19 stands
2	Boner 1979	Great Smoky Mountains-->=1830m	Circular 0.04-ha plots in 27 stands
3	Carbonneau 1986a	Eagle Cliff--SF-3	2-7 20 m x 20 m plots
3	Carbonneau 1986a	Gibbs Brook--SF-2	2-7 20 m x 20 m plots
3	Carbonneau 1986a	Nancy Brook--SF-1	2-7 20 m x 20 m plots
3	Carbonneau 1986a	Norton Pool--SF-4	2-7 20 m x 20 m plots
4	Cogbill 1985	Big Reed Pond--Red Spruce-Fir	Field assessment; tree cores
4	Cogbill 1985	Big Reed Pond--Red Spruce-Mixed	Field assessment; tree cores
5	Cogbill 1996	Basin Ponds	1 20 m x 50 m plot
5	Cogbill 1996	Bernard Mountain	2 20 m x 30 m plots
5	Cogbill 1996	Big Reed	1 20 m x 50 m plot
5	Cogbill 1996	Dry Town	1 20 m x 50 m plot
5	Cogbill 1996	East Mountain	1 20 m x 50 m plot
5	Cogbill 1996	Elephant Mountain	1 20 m x 50 m plot
5	Cogbill 1996	Gill Brook	1 20 m x 50 m plot
5	Cogbill 1996	Lake Arnold	1 20 m x 50 m plot [1]
5	Cogbill 1996	Nancy Brook	2-7 20 m x 20 m plots [2]
5	Cogbill 1996	North Turner Brook	1 20 m x 50 m plot
5	Cogbill 1996	Norton Pool	2-7 20 m x 20 m plots [2]
5	Cogbill 1996	Phelps Mountain	1 20 m x 50 m plot
5	Cogbill 1996	The Bowl	1 20 m x 50 m plot
5	Cogbill 1996	Wizard Pond	1 20 m x 50 m plot
6	Crandall 1958	Great Smoky Mountains (GSM)	1 or 2 strip plots [5 m or 10 m x 50 m] per site type
6	Crandall 1958	GSM--Fir Type-O-H T [3]	Sample of 1000-m^2 total
6	Crandall 1958	GSM--Fir Type-O-D T	Sample of 1000-m^2 total
6	Crandall 1958	GSM--Fir Type-Vi-Va-D T	Sample of 1000-m^2 total
6	Crandall 1958	GSM--Fir Type-Se T	Sample of 1000-m^2 total
6	Crandall 1958	GSM--Spruce-Fir Type-O-H T	Sample of 1000-m^2 total
6	Crandall 1958	GSM--Spruce-Fir Type-H-Va T	Sample of 1000-m^2 total
6	Crandall 1958	GSM--Spruce-Fir Type-Vi-Va-D T	Sample of 1000-m^2 total
6	Crandall 1958	GSM--Spruce-Fir Type-Vi-Va-Se T	Sample of 1000-m^2 total
6	Crandall 1958	GSM--Spruce-Fir Type-R T	Sample of 1000-m^2 total
6	Crandall 1958	GSM--Spruce-Fir Type-R (Vi) T	Sample of 1000-m^2 total
6	Crandall 1958	GSM--Spruce Type-H-Va T	Sample of 500-m^2 total
6	Crandall 1958	GSM--Spruce Type-Vi-Va-D T	Sample of 500-m^2 total
6	Crandall 1958	GSM--Spruce Type-Vi-Va-L T	Sample of 500-m^2 total

(Table 79 continued on next page)

(Table 79 continued)

Map Key	Source/Date	Stand	Sampling Methods
6	Crandall 1958	GSM--Spruce Type-R T	Sample of 500-m^2 total
6	Crandall 1958	GSM--Spruce Type-R (Vi) T	Sample of 500-m^2 total
6	Crandall 1958	GSM--Spruce-Hardwood Type-Vi T	Sample of 500-m^2 total
6	Crandall 1958	GSM--Spruce-Hardwood Type-As T	Sample of 500-m^2 total
6	Crandall 1958	GSM--Spruce-Hardwood Type-R T	Sample of 500-m^2 total
7	Davis 1966	Ironbound Island	10 m x 10 m plots
7	Davis 1966	Otter Point	10 m x 10 m plots
7	Davis 1966	Western Mountain	10 m x 10 m plots
8	Fitzgerald and Raynal 1991	Whiteface Mountain--900 m	18 10-m circular plots centered on red spruce
8	Fitzgerald and Raynal 1991	Whiteface Mountain--1100 m	18 10-m circular plots centered on red spruce
9	Foster and Reiners 1983	Basin Ponds	Field assessment [4]
9	Foster and Reiners 1983	Bernard Mountain	Field assessment [4]
9	Foster and Reiners 1983	Gibbs Brook--825 m	5 m x 5 m quadrats in grids 875-2500 m^2
9	Foster and Reiners 1983	Gibbs Brook--890 m	5 m x 5 m quadrats in grids 875-2500 m^2
9	Foster and Reiners 1983	Gibbs Brook--955 m	5 m x 5 m quadrats in grids 875-2500 m^2
9	Foster and Reiners 1983	Gibbs Brook--1020 m	5 m x 5 m quadrats in grids 875-2500 m^2
9	Foster and Reiners 1983	North Traveler Mountain	Field assessment [4]
10	Graves 1899	Nehasane Park--spruce flats	Strip plots totalling 43 ha
10	Graves 1899	Nehasane Park--spruce slopes	Strip plots totalling 111 ha
10	Graves 1899	Nehasane Park--swamp lands	Strip plots totalling 91 ha
11	Hosmer and Bruce 1901	Township 40--spruce lower slopes	Measurements of trees on 386-ha sample
11	Hosmer and Bruce 1901	Township 40--swamp	Measurements of trees on 36-ha sample
11	Hosmer and Bruce 1901	Township 40--upper spruce slopes	Measurements of trees on 15-ha sample
12	Korstian 1937	Black Mountains	4 plots, totalling 0.57 ha
12	Korstian 1937	Pisgah Ridge	0.4-ha strip plot
12	Korstian 1937	Turkey Run	0.2-ha strip plot
12	Korstian 1937	Unaka Mountain	0.4-ha strip plot
13	Leak 1985b	Nancy Brook	Cores of red spruce (56), balsam fir (50)
13	Leak 1985b	The Bowl	Cores of red spruce (21); plots for diameter distribution
14	Leak 1987b	Bartlett--Bedrock-500-550 m-1932	2 0.1-ha plots
14	Leak 1987b	Bartlett--Bedrock-500-550 m-1984	2 0.1-ha plots
14	Leak 1987b	Bartlett--Bedrock-650 m-1932	0.1-ha plot
14	Leak 1987b	Bartlett--Bedrock-650 m-1984	0.1-ha plot
15	Leak and Graber 1974	Mt. Whiteface/The Bowl	Prism plots at 50-m elevation intervals
16	LeBlanc 1990	Whiteface Mountain	Growth analysis of 46 spruce cut in two sites
17	Leopold et al. 1988	Phelps Brook	3 plots, 375-450 m^2
18	Maine Critical Areas Program 1983b	Basin Ponds	Old-growth inventory; cores
18	Maine Critical Areas Program 1983b	Bernard Mountain	2 0.06-ha plots; cores
18	Maine Critical Areas Program 1983b	Cathedral Woods	Old-growth inventory; cores
18	Maine Critical Areas Program 1983b	Crocker Mountain	Old-growth inventory; cores

(Table 79 continued on next page)

(Table 79 continued)

Map Key	Source/Date	Stand	Sampling Methods
18	Maine Critical Areas Program 1983b	East Royce Mountain	Old-growth inventory; cores
18	Maine Critical Areas Program 1983b	Elephant Mountain	Old-growth inventory; cores
18	Maine Critical Areas Program 1983b	Hurd Mountain	Old-growth inventory; cores
18	Maine Critical Areas Program 1983b	Jonesborough	5 10-factor prism plots; cores
18	Maine Critical Areas Program 1983b	Mooseleuk Mountain	Old-growth inventory
18	Maine Critical Areas Program 1983b	Nestuntabunt Mountain	Old-growth inventory; cores
18	Maine Critical Areas Program 1983b	North Traveler	Old-growth inventory; 2 plots totalling 680 m^2; cores
18	Maine Critical Areas Program 1983b	No. 9 Mountain	Old-growth inventory; cores
18	Maine Critical Areas Program 1983b	Priestly Mountain	Old-growth inventory; cores
18	Maine Critical Areas Program 1983b	Roque Island	2 0.05-ha plots; cores
18	Maine Critical Areas Program 1983b	Sugarloaf-Burnt Hill Saddle	Old-growth inventory; cores
18	Maine Critical Areas Program 1983b	T13 R11 Red Spruce	Old-growth inventory; cores
18	Maine Critical Areas Program 1983b	Traveler Mountain	10 prism plots
18	Maine Critical Areas Program 1983b	Wassataquoik Lake	Old-growth inventory; cores
19	Maine State Planning Office 1986	Black Mountain	Inventory, cores
19	Maine State Planning Office 1986	Center Mountain	Inventory, cores
19	Maine State Planning Office 1986	Crater-Denny-Galilee	Inventory, cores
19	Maine State Planning Office 1986	Deboullie Mountain	Inventory, cores
19	Maine State Planning Office 1986	East Nubble Red Spruce	Inventory, cores
19	Maine State Planning Office 1986	Gardner Mountain	Inventory, cores
19	Maine State Planning Office 1986	Mahoosuc Mountain	Inventory, cores
19	Maine State Planning Office 1986	Pushineer Pond	Inventory, cores
19	Maine State Planning Office 1986	Wassataquiok Mountain	Inventory, cores
20	McIntosh and Hurley 1964	Catskills--22 stands	20 point-quarters per stand; cores from 69 spruce trees, 77 firs
21	McMartin 1994	Big Moose Lake	172-tree sample
21	McMartin 1994	Powley--Red Spruce/Mixed Stand	125-tree sample
21	McMartin 1994	Powley--Spruce Flat	95-tree sample
21	McMartin 1994	Stillwater Reservoir	123-tree sample
22	Oosting and Billings 1951	Great Smoky Mountains (9 stands)	10 10 m x 10 m plots in each stand
22	Oosting and Billings 1951	White Mountains (4 stands)	10 10 m x 10 m plots in each stand
23	Reiners and Lang 1979	Three areas in White Mountains	11 series of 2-m belt transects in 20 m segments
24	Rheinhardt and Ware 1984	Balsam Mountains--Spruce	3 stands sampled with Bitterlich points along transects
24	Rheinhardt and Ware 1984	Balsam Mountains--Spruce-Fir	2 stands sampled with Bitterlich points along transects
25	Roman 1980	Adirondacks--Poor Fen	1 0.05-ha plot in each of 5 stands
25	Roman 1980	Adirondacks--Rich Fen	1 0.05-ha plot in each of 2 stands
25	Roman 1980	Adirondacks--Upland Mixed-red spruce	1 0.1-ha plot in each of 10 stands
26	Sprugel 1976	Whiteface Mountain--Esther/Lookout	200 trees at edges of fir "waves"
27	Stephenson and Adams 1984	Mount Rogers--5 stands near summit	1 20 m x 50 m quadrat in each stand
27	Stephenson and Adams 1984	Mount Rogers--NE Slope	1 20 m x 50 m quadrat
27	Stephenson and Adams 1984	Mount Rogers--NW Slope	1 20 m x 50 m quadrat

(Table 79 continued on next page)

(Table 79 continued)

Map Key	Source/Date	Stand	Sampling Methods
27	Stephenson and Adams 1984	Mount Rogers--Ridgetop	1 20 m x 50 m quadrat
27	Stephenson and Adams 1984	Mount Rogers--SE Slope	1 20 m x 50 m quadrat
27	Stephenson and Adams 1984	Mount Rogers--SW Slope	1 20 m x 50 m quadrat
28	Weaver 1972	Balsam Mountains	40 0.04-ha plots throughout study area
29	White et al. 1985	Great Smoky Mountains--Mt. Collins	10 random prism plots

[1] From Woods and Cogbill (1994).

[2] Data from Lee Carbonneau, personal communication and Carbonneau (1986).

[3] For explanation of community types see Table 77, Endnote 2 .

[4] Cited in Foster and Reiners (1983) as Cogbill, personal communication.

Table 80.—*Density of live trees ≥10, ≥50, and ≥70 cm for montane and allied spruce-fir old-growth study sites. For other minimum sizes, the density is listed under "≥X cm", with the minimum size for tallying trees given as "Min Diam X (cm)".*

			Live Tree Density				
Map Key	Source/Date	Stand	≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X cm (#/ha)	Min Diam X (cm)
1	Adams and Stephenson 1989	Gaudineer Knob	455	40	10 [1]	1410	2.5
1	Adams and Stephenson 1989	Salt Pond Mountain	520	30	20 [1]	875	2.5
1	Adams and Stephenson 1989	Shavers Mountain	500	20	5 [1]	925	2.5
1	Adams and Stephenson 1989	Turkey Run	425	45	0 [1]	855	2.5
2	Boner 1979	Great Smoky Mountains--<1830m				692	12.7
2	Boner 1979	Great Smoky Mountains-->=1830m				876	12.7
3	Carbonneau 1986a	Eagle Cliff--SF-3	576				
3	Carbonneau 1986a	Gibbs Brook--SF-2	1124				
3	Carbonneau 1986a	Nancy Brook--SF-1	1035				
3	Carbonneau 1986a	Norton Pool--SF-4	469				
4	Cogbill 1985	Big Reed Pond--Red Spruce-Fir					
4	Cogbill 1985	Big Reed Pond--Red Spruce-Mixed					
5	Cogbill 1996	Basin Ponds				420	20
5	Cogbill 1996	Bernard Mountain				341	20
5	Cogbill 1996	Big Reed				521	20
5	Cogbill 1996	Dry Town				289	20
5	Cogbill 1996	East Mountain				321	20
5	Cogbill 1996	Elephant Mountain				538	20
5	Cogbill 1996	Gill Brook				290	20
5	Cogbill 1996	Lake Arnold				320	20
5	Cogbill 1996	Nancy Brook				274	20
5	Cogbill 1996	North Turner Brook				341	20
5	Cogbill 1996	Norton Pool				220	20
5	Cogbill 1996	Phelps Mountain				420	20
5	Cogbill 1996	The Bowl				210	20
5	Cogbill 1996	Wizard Pond				460	20
6	Crandall 1958	Great Smoky Mountains (GSM)					
6	Crandall 1958	GSM--Fir Type-O-H T [2]					
6	Crandall 1958	GSM--Fir Type-O-D T					
6	Crandall 1958	GSM--Fir Type-Vi-Va-D T					
6	Crandall 1958	GSM--Fir Type-Se T					
6	Crandall 1958	GSM--Spruce-Fir Type-O-H T					
6	Crandall 1958	GSM--Spruce-Fir Type-H-Va T					
6	Crandall 1958	GSM--Spruce-Fir Type-Vi-Va-D T					
6	Crandall 1958	GSM--Spruce-Fir Type-Vi-Va-Se T					
6	Crandall 1958	GSM--Spruce-Fir Type-R T					
6	Crandall 1958	GSM--Spruce-Fir Type-R (Vi) T					
6	Crandall 1958	GSM--Spruce Type-H-Va T					
6	Crandall 1958	GSM--Spruce Type-Vi-Va-D T					
6	Crandall 1958	GSM--Spruce Type-Vi-Va-L T					

(Table 80 continued on next page)

(Table 80 continued)

Map Key	Source/Date	Stand	Live Tree Density ≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X cm (#/ha)	Min Diam X (cm)
6	Crandall 1958	GSM--Spruce Type-R T					
6	Crandall 1958	GSM--Spruce Type-R (Vi) T					
6	Crandall 1958	GSM--Spruce-Hardwood Type-Vi T					
6	Crandall 1958	GSM--Spruce-Hardwood Type-As T					
6	Crandall 1958	GSM--Spruce-Hardwood Type-R T					
7	Davis 1966	Ironbound Island					
7	Davis 1966	Otter Point					
7	Davis 1966	Western Mountain	740				
8	Fitzgerald and Raynal 1991	Whiteface Mountain--900 m				365[3]	unspecified
8	Fitzgerald and Raynal 1991	Whiteface Mountain--1100 m				553[3]	unspecified
9	Foster and Reiners 1983	Basin Ponds				1909	2.5
9	Foster and Reiners 1983	Bernard Mountain				1833	2.5
9	Foster and Reiners 1983	Gibbs Brook--825 m				376	20
9	Foster and Reiners 1983	Gibbs Brook--890 m				370	20
9	Foster and Reiners 1983	Gibbs Brook--955 m				594	20
9	Foster and Reiners 1983	Gibbs Brook--1020 m				558	20
9	Foster and Reiners 1983	North Traveler Mountain				2024	2.5
10	Graves 1899	Nehasane Park--spruce flats				159[4]	25.4
10	Graves 1899	Nehasane Park--spruce slopes				173[4]	25.4
10	Graves 1899	Nehasane Park--swamp lands				175[4]	25.4
11	Hosmer and Bruce 1901	Township 40--spruce lower slopes				130[4]	25.4
11	Hosmer and Bruce 1901	Township 40--swamp				90[4]	25.4
11	Hosmer and Bruce 1901	Township 40--upper spruce slopes				118[4]	25.4
12	Korstian 1937	Black Mountains	385			479	>1.4 m
12	Korstian 1937	Pisgah Ridge	457			511	>1.4 m
12	Korstian 1937	Turkey Run	1324			1230	>1.4 m
12	Korstian 1937	Unaka Mountain	692			1660	>1.4 m
13	Leak 1985b	Nancy Brook					
13	Leak 1985b	The Bowl					
14	Leak 1987b	Bartlett--Bedrock-500-550 m-1932					
14	Leak 1987b	Bartlett--Bedrock-500-550 m-1984					
14	Leak 1987b	Bartlett--Bedrock-650 m-1932					
14	Leak 1987b	Bartlett--Bedrock-650 m-1984					
15	Leak and Graber 1974	Mt. Whiteface/The Bowl					
16	LeBlanc 1990	Whiteface Mountain					
17	Leopold et al. 1988	Phelps Brook				1333	5
18	Maine Critical Areas Program 1983b	Basin Ponds					
18	Maine Critical Areas Program 1983b	Bernard Mountain	833				
18	Maine Critical Areas Program 1983b	Cathedral Woods					
18	Maine Critical Areas Program 1983b	Crocker Mountain					

(Table 80 continued on next page)

(Table 80 continued)

			Live Tree Density				
Map Key	Source/Date	Stand	≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X cm (#/ha)	Min Diam X (cm)
18	Maine Critical Areas Program 1983b	East Royce Mountain					
18	Maine Critical Areas Program 1983b	Elephant Mountain					
18	Maine Critical Areas Program 1983b	Hurd Mountain					
18	Maine Critical Areas Program 1983b	Jonesborough					
18	Maine Critical Areas Program 1983b	Mooseleuk Mountain					
18	Maine Critical Areas Program 1983b	Nestuntabunt Mountain					
18	Maine Critical Areas Program 1983b	North Traveler	824				
18	Maine Critical Areas Program 1983b	No. 9 Mountain					
18	Maine Critical Areas Program 1983b	Priestly Mountain					
18	Maine Critical Areas Program 1983b	Roque Island	880				
18	Maine Critical Areas Program 1983b	Sugarloaf-Burnt Hill Saddle					
18	Maine Critical Areas Program 1983b	T13 R11 Red Spruce					
18	Maine Critical Areas Program 1983b	Traveler Mountain					
18	Maine Critical Areas Program 1983b	Wassataquoik Lake					
19	Maine State Planning Office 1986	Black Mountain					
19	Maine State Planning Office 1986	Center Mountain					
19	Maine State Planning Office 1986	Crater-Denny-Galilee					
19	Maine State Planning Office 1986	Deboullie Mountain					
19	Maine State Planning Office 1986	East Nubble Red Spruce					
19	Maine State Planning Office 1986	Gardner Mountain					
19	Maine State Planning Office 1986	Mahoosuc Mountain					
19	Maine State Planning Office 1986	Pushineer Pond					
19	Maine State Planning Office 1986	Wassataquiok Mountain					
20	McIntosh and Hurley 1964	Catskills--22 stands					
21	McMartin 1994	Big Moose Lake					
21	McMartin 1994	Powley--Red Spruce/Mixed Stand					
21	McMartin 1994	Powley--Spruce Flat					
21	McMartin 1994	Stillwater Reservoir					
22	Oosting and Billings 1951	Great Smoky Mountains (9 stands)				1720[5]	2.5
22	Oosting and Billings 1951	White Mountains (4 stands)				3310[5]	2.5
23	Reiners and Lang 1979	Three areas in White Mountains				5000[6]	> 2 m ht
24	Rheinhardt and Ware 1984	Balsam Mountains--Spruce					
24	Rheinhardt and Ware 1984	Balsam Mountains--Spruce-Fir					
25	Roman 1980	Adirondacks--Poor Fen	624				
25	Roman 1980	Adirondacks--Rich Fen	760				
25	Roman 1980	Adirondacks--Upland Mixed-red spruce	835				
26	Sprugel 1976	Whiteface Mountain--Esther/Lookout					
27	Stephenson and Adams 1984	Mount Rogers--5 stands near summit	1066			152	30
27	Stephenson and Adams 1984	Mount Rogers--NE Slope	550				
27	Stephenson and Adams 1984	Mount Rogers--NW Slope	1310				

(Table 80 continued on next page)

(Table 80 continued)

			Live Tree Density				
Map Key	Source/Date	Stand	≥10 cm (#/ha)	≥50 cm (#/ha)	≥70 cm (#/ha)	≥X cm (#/ha)	Min Diam X (cm)
27	Stephenson and Adams 1984	Mount Rogers--Ridgetop	1750				
27	Stephenson and Adams 1984	Mount Rogers--SE Slope	780				
27	Stephenson and Adams 1984	Mount Rogers--SW Slope	940				
28	Weaver 1972	Balsam Mountains				1927	5.08
29	White et al. 1985	Great Smoky Mountains--Mt. Collins				570 [7]	>1.4 m tall

[1] Value listed under density >70 is actually density >60 cm d.b.h.

[2] For explanation of community types see Table 77, Endnote 2.

[3] Density are sums for balsam fir, red spruce, and hardwoods.

[4] Density of sound trees.

[5] Density for red spruce and balsam fir only.

[6] Density ranged from 1,700 - 14,400/ha.

[7] Density is for Fraser fir, red spruce, and yellow birch combined.

Table 81.—*Basal area of live trees ≥10, ≥50, and ≥70 cm for montane and allied spruce-fir old-growth study sites. For other minimum sizes, the basal area is listed under "≥X cm", with the minimum size for tallying trees given as "Min Diam X (cm)".*

			Live Tree Basal Area (BA)				
Map Key	Source/Date	Stand	≥10 cm (m^2/ha)	≥50 cm (m^2/ha)	≥70 cm (m^2/ha)	≥X cm (m^2/ha)	Min Diam X (cm)
1	Adams and Stephenson 1989	Gaudineer Knob	37.7			40.1	2.5
1	Adams and Stephenson 1989	Salt Pond Mountain	45.0			46.2	2.5
1	Adams and Stephenson 1989	Shavers Mountain	35.1			36.1	2.5
1	Adams and Stephenson 1989	Turkey Run	33.9			35.3	2.5
2	Boner 1979	Great Smoky Mountains--<1830m				53.3	12.7
2	Boner 1979	Great Smoky Mountains-->=1830m				47.2	12.7
3	Carbonneau 1986a	Eagle Cliff--SF-3	29.6				
3	Carbonneau 1986a	Gibbs Brook--SF-2	44.0				
3	Carbonneau 1986a	Nancy Brook--SF-1	34.6				
3	Carbonneau 1986a	Norton Pool--SF-4	22.8				
4	Cogbill 1985	Big Reed Pond--Red Spruce-Fir	24.9				
4	Cogbill 1985	Big Reed Pond--Red Spruce-Mixed	24.5				
5	Cogbill 1996	Basin Ponds				40.9	20
5	Cogbill 1996	Bernard Mountain				42.0	20
5	Cogbill 1996	Big Reed				49.5	20
5	Cogbill 1996	Dry Town				35.3	20
5	Cogbill 1996	East Mountain				34.3	20
5	Cogbill 1996	Elephant Mountain				42.7	20
5	Cogbill 1996	Gill Brook				33.1	20
5	Cogbill 1996	Lake Arnold				37.7	20
5	Cogbill 1996	Nancy Brook				28.5	20
5	Cogbill 1996	North Turner Brook				32.0	20
5	Cogbill 1996	Norton Pool				22.0	20
5	Cogbill 1996	Phelps Mountain				39.7	20
5	Cogbill 1996	The Bowl				28.9	20
5	Cogbill 1996	Wizard Pond				47.0	20
6	Crandall 1958	Great Smoky Mountains (GSM)					
6	Crandall 1958	GSM--Fir Type-O-H T[1]				27.5-52.3	12.7
6	Crandall 1958	GSM--Fir Type-O-D T				37.6-53.3	12.7
6	Crandall 1958	GSM--Fir Type-Vi-Va-D T				50.5	12.7
6	Crandall 1958	GSM--Fir Type-Se T				35.8	12.7
6	Crandall 1958	GSM--Spruce-Fir Type-O-H T				42.2-45.9	12.7
6	Crandall 1958	GSM--Spruce-Fir Type-H-Va T				40.4-55.1	12.7
6	Crandall 1958	GSM--Spruce-Fir Type-Vi-Va-D T				49.6-71.6	12.7
6	Crandall 1958	GSM--Spruce-Fir Type-Vi-Va-Se T				52.3-72.5	12.7
6	Crandall 1958	GSM--Spruce-Fir Type-R T				27.5-37.6	12.7
6	Crandall 1958	GSM--Spruce-Fir Type-R (Vi) T				51.4	12.7
6	Crandall 1958	GSM--Spruce Type-H-Va T				38.6-45.9	12.7
6	Crandall 1958	GSM--Spruce Type-Vi-Va-D T				61.8-84.5	12.7
6	Crandall 1958	GSM--Spruce Type-Vi-Va-L T				57.9-77.1	12.7

(Table 81 continued on next page)

(Table 81 continued)

			Live Tree Basal Area (BA)				
Map Key	Source/Date	Stand	≥10 cm (m^2/ha)	≥50 cm (m^2/ha)	≥70 cm (m^2/ha)	≥X cm (m^2/ha)	Min Diam X (cm)
6	Crandall 1958	GSM--Spruce Type-R T				55.1-61.5	12.7
6	Crandall 1958	GSM--Spruce Type-R (Vi) T				46.8-67.0	12.7
6	Crandall 1958	GSM--Spruce-Hardwood Type-Vi T				27.5-52.3	12.7
6	Crandall 1958	GSM--Spruce-Hardwood Type-As T				41.3-56.9	12.7
6	Crandall 1958	GSM--Spruce-Hardwood Type-R T				35.4	12.7
7	Davis 1966	Ironbound Island					
7	Davis 1966	Otter Point					
7	Davis 1966	Western Mountain	41.6 [2]				
8	Fitzgerald and Raynal 1991	Whiteface Mountain--900 m				16.4 [3]	unspecified
8	Fitzgerald and Raynal 1991	Whiteface Mountain--1100 m				20.2 [3]	unspecified
9	Foster and Reiners 1983	Basin Ponds				58.7	2.5
9	Foster and Reiners 1983	Bernard Mountain				45.2	2.5
9	Foster and Reiners 1983	Gibbs Brook--825 m				29.7	20
9	Foster and Reiners 1983	Gibbs Brook--890 m				32.7	20
9	Foster and Reiners 1983	Gibbs Brook--955 m				34.7	20
9	Foster and Reiners 1983	Gibbs Brook--1020 m				36.2	20
9	Foster and Reiners 1983	North Traveler Mountain				41.1	2.5
10	Graves 1899	Nehasane Park--spruce flats					
10	Graves 1899	Nehasane Park--spruce slopes					
10	Graves 1899	Nehasane Park--swamp lands					
11	Hosmer and Bruce 1901	Township 40--spruce lower slopes					
11	Hosmer and Bruce 1901	Township 40--swamp					
11	Hosmer and Bruce 1901	Township 40--upper spruce slopes					
12	Korstian 1937	Black Mountains					
12	Korstian 1937	Pisgah Ridge					
12	Korstian 1937	Turkey Run					
12	Korstian 1937	Unaka Mountain					
13	Leak 1985b	Nancy Brook					
13	Leak 1985b	The Bowl					
14	Leak 1987b	Bartlett--Bedrock-500-550 m-1932				23.9	11.5
14	Leak 1987b	Bartlett--Bedrock-500-550 m-1984				40.9	11.5
14	Leak 1987b	Bartlett--Bedrock-650 m-1932				41.0	11.5
14	Leak 1987b	Bartlett--Bedrock-650 m-1984				41.6	11.5
15	Leak and Graber 1974	Mt. Whiteface/The Bowl					
16	LeBlanc 1990	Whiteface Mountain					
17	Leopold et al. 1988	Phelps Brook				30.5	5
18	Maine Critical Areas Program 1983b	Basin Ponds					
18	Maine Critical Areas Program 1983b	Bernard Mountain	42.1				
18	Maine Critical Areas Program 1983b	Cathedral Woods					
18	Maine Critical Areas Program 1983b	Crocker Mountain					

(Table 81 continued on next page)

(Table 81 continued)

			Live Tree Basal Area (BA)				
Map Key	Source/Date	Stand	≥10 cm (m²/ha)	≥50 cm (m²/ha)	≥70 cm (m²/ha)	≥X cm (m²/ha)	Min Diam X (cm)
18	Maine Critical Areas Program 1983b	East Royce Mountain					
18	Maine Critical Areas Program 1983b	Elephant Mountain					
18	Maine Critical Areas Program 1983b	Hurd Mountain					
18	Maine Critical Areas Program 1983b	Jonesborough					
18	Maine Critical Areas Program 1983b	Mooseleuk Mountain					
18	Maine Critical Areas Program 1983b	Nestuntabunt Mountain					
18	Maine Critical Areas Program 1983b	North Traveler	37.5				
18	Maine Critical Areas Program 1983b	No. 9 Mountain					
18	Maine Critical Areas Program 1983b	Priestly Mountain					
18	Maine Critical Areas Program 1983b	Roque Island	50.6				
18	Maine Critical Areas Program 1983b	Sugarloaf-Burnt Hill Saddle					
18	Maine Critical Areas Program 1983b	T13 R11 Red Spruce					
18	Maine Critical Areas Program 1983b	Traveler Mountain					
18	Maine Critical Areas Program 1983b	Wassataquoik Lake					
19	Maine State Planning Office 1986	Black Mountain					
19	Maine State Planning Office 1986	Center Mountain					
19	Maine State Planning Office 1986	Crater-Denny-Galilee					
19	Maine State Planning Office 1986	Deboullie Mountain					
19	Maine State Planning Office 1986	East Nubble Red Spruce					
19	Maine State Planning Office 1986	Gardner Mountain					
19	Maine State Planning Office 1986	Mahoosuc Mountain					
19	Maine State Planning Office 1986	Pushineer Pond					
19	Maine State Planning Office 1986	Wassataquiok Mountain					
20	McIntosh and Hurley 1964	Catskills--22 stands					
21	McMartin 1994	Big Moose Lake					
21	McMartin 1994	Powley--Red Spruce/Mixed Stand					
21	McMartin 1994	Powley--Spruce Flat					
21	McMartin 1994	Stillwater Reservoir					
22	Oosting and Billings 1951	Great Smoky Mountains (9 stands)	58.7 [4,5]				
22	Oosting and Billings 1951	White Mountains (4 stands)	63.3 [4,5]				
23	Reiners and Lang 1979	Three areas in White Mountains				29.8 [6]	> 2.0 m tall
24	Rheinhardt and Ware 1984	Balsam Mountains--Spruce				33.0	>1.4 m tall
24	Rheinhardt and Ware 1984	Balsam Mountains--Spruce-Fir				38.0	>1.4 m tall
25	Roman 1980	Adirondacks--Poor Fen	13.8				
25	Roman 1980	Adirondacks--Rich Fen	45.6				
25	Roman 1980	Adirondacks--Upland Mixed-red spruce	38.9				
26	Sprugel 1976	Whiteface Mountain--Esther/Lookout					
27	Stephenson and Adams 1984	Mount Rogers--5 stands near summit	43.0				
27	Stephenson and Adams 1984	Mount Rogers--NE Slope	35.9				
27	Stephenson and Adams 1984	Mount Rogers--NW Slope	43.3				

(Table 81 continued on next page)

(Table 81 continued)

			Live Tree Basal Area (BA)				
Map Key	Source/Date	Stand	≥10 cm (m^2/ha)	≥50 cm (m^2/ha)	≥70 cm (m^2/ha)	≥X cm (m^2/ha)	Min Diam X (cm)
27	Stephenson and Adams 1984	Mount Rogers--Ridgetop	44.9				
27	Stephenson and Adams 1984	Mount Rogers--SE Slope	44.5				
27	Stephenson and Adams 1984	Mount Rogers--SW Slope	46.3				
28	Weaver 1972	Balsam Mountains				51.6	5.08?
29	White et al. 1985	Great Smoky Mountains--Mt. Collins					

[1] For explanation of community types see Table 77, Endnote 2.

[2] Basal area for spruce and fir only.

[3] Basal area is for balsam fir, red spruce, and hardwoods; not total basal area.

[4] Basal area for red spruce and balsam fir only.

[5] Average basal area for red spruce in North Carolina and Tennessee stands was 31.4 m^2/ha and for fir was 19.7 m^2/ha.

[6] Basal area ranged from 9.9 to 49.3 m^2/ha.

Table 82.—*Average and maximum tree age by species for montane and allied spruce-fir old-growth study sites.*

Map Key	Source/Date	Stand	Average Tree Age (yr) Red Spruce	Average Tree Age (yr) Balsam Fir	Average Tree Age (yr) White Spruce	Average Tree Age (yr) Fraser Fir	Maximum Tree Age (yr) Red Spruce	Maximum Tree Age (yr) Balsam Fir	Maximum Tree Age (yr) White Spruce	Maximum Tree Age (yr) Fraser Fir
1	Adams and Stephenson 1989	Gaudineer Knob	200				368			
1	Adams and Stephenson 1989	Salt Pond Mountain	196				253			
1	Adams and Stephenson 1989	Shavers Mountain	201				274			
1	Adams and Stephenson 1989	Turkey Run	164				278			
2	Boner 1979	Great Smoky Mountains--<1830m								
2	Boner 1979	Great Smoky Mountains-->=1830m								
3	Carbonneau 1986a	Eagle Cliff--SF-3								
3	Carbonneau 1986a	Gibbs Brook--SF-2								
3	Carbonneau 1986a	Nancy Brook--SF-1								
3	Carbonneau 1986a	Norton Pool--SF-4								
4	Cogbill 1985	Big Reed Pond--Red Spruce-Fir	100				161+[1]			
4	Cogbill 1985	Big Reed Pond--Red Spruce-Mixed	100				161+[1]			
5	Cogbill 1996	Basin Ponds	232				380			
5	Cogbill 1996	Bernard Mountain	177				242			
5	Cogbill 1996	Big Reed	170				300			
5	Cogbill 1996	Dry Town	166				225			
5	Cogbill 1996	East Mountain	158				258			
5	Cogbill 1996	Elephant Mountain	194				320			
5	Cogbill 1996	Gill Brook	146				255			
5	Cogbill 1996	Lake Arnold	233				248			
5	Cogbill 1996	Nancy Brook	254				415			
5	Cogbill 1996	North Turner Brook	242				423			
5	Cogbill 1996	Norton Pool	240				303			
5	Cogbill 1996	Phelps Mountain	215				308			
5	Cogbill 1996	The Bowl	200				260			
5	Cogbill 1996	Wizard Pond	206				291			
6	Crandall 1958	Great Smoky Mountains (GSM)								
6	Crandall 1958	GSM--Fir Type-O-H T[2]								
6	Crandall 1958	GSM--Fir Type-O-D T								
6	Crandall 1958	GSM--Fir Type-Vi-Va-D T								
6	Crandall 1958	GSM--Fir Type-Se T								
6	Crandall 1958	GSM--Spruce-Fir Type-O-H T								
6	Crandall 1958	GSM--Spruce-Fir Type-H-Va T								
6	Crandall 1958	GSM--Spruce-Fir Type-Vi-Va-D T								
6	Crandall 1958	GSM--Spruce-Fir Type-Vi-Va-Se T								
6	Crandall 1958	GSM--Spruce-Fir Type-R T								
6	Crandall 1958	GSM--Spruce-Fir Type-R (Vi) T								
6	Crandall 1958	GSM--Spruce Type-H-Va T								
6	Crandall 1958	GSM--Spruce Type-Vi-Va-D T								
6	Crandall 1958	GSM--Spruce Type-Vi-Va-L T								

(Table 82 continued on next page)

(Table 82 continued)

Map Key	Source/Date	Stand	Average Tree Age (yr) Red Spruce	Average Tree Age (yr) Balsam Fir	Average Tree Age (yr) White Spruce	Average Tree Age (yr) Fraser Fir	Maximum Tree Age (yr) Red Spruce	Maximum Tree Age (yr) Balsam Fir	Maximum Tree Age (yr) White Spruce	Maximum Tree Age (yr) Fraser Fir
6	Crandall 1958	GSM--Spruce Type-R T								
6	Crandall 1958	GSM--Spruce Type-R (Vi) T								
6	Crandall 1958	GSM--Spruce-Hardwood Type-Vi T								
6	Crandall 1958	GSM--Spruce-Hardwood Type-As T								
6	Crandall 1958	GSM--Spruce-Hardwood Type-R T								
7	Davis 1966	Ironbound Island					138			
7	Davis 1966	Otter Point					225		125	
7	Davis 1966	Western Mountain	163				250			
8	Fitzgerald and Raynal 1991	Whiteface Mountain--900 m		56				121		
8	Fitzgerald and Raynal 1991	Whiteface Mountain--1100 m		66				161		
9	Foster and Reiners 1983	Basin Ponds					320 ^{3}			
9	Foster and Reiners 1983	Bernard Mountain					250 ^{3}			
9	Foster and Reiners 1983	Gibbs Brook--825 m					321 ^{3}			
9	Foster and Reiners 1983	Gibbs Brook--890 m					189 ^{3}			
9	Foster and Reiners 1983	Gibbs Brook--955 m					240 ^{3}			
9	Foster and Reiners 1983	Gibbs Brook--1020 m					320 ^{3}			
9	Foster and Reiners 1983	North Traveler Mountain					301 ^{3}			
10	Graves 1899	Nehasane Park--spruce flats					310 ^{4}			
10	Graves 1899	Nehasane Park--spruce slopes					}			
10	Graves 1899	Nehasane Park--swamp lands					}			
11	Hosmer and Bruce 1901	Township 40--spruce lower slopes								
11	Hosmer and Bruce 1901	Township 40--swamp								
11	Hosmer and Bruce 1901	Township 40--upper spruce slopes								
12	Korstian 1937	Black Mountains								
12	Korstian 1937	Pisgah Ridge								
12	Korstian 1937	Turkey Run								
12	Korstian 1937	Unaka Mountain								
13	Leak 1985b	Nancy Brook					390	202		
13	Leak 1985b	The Bowl					264 ^{5}			
14	Leak 1987b	Bartlett--Bedrock-500-550 m-1932								
14	Leak 1987b	Bartlett--Bedrock-500-550 m-1984								
14	Leak 1987b	Bartlett--Bedrock-650 m-1932								
14	Leak 1987b	Bartlett--Bedrock-650 m-1984								
15	Leak and Graber 1974	Mt. Whiteface/The Bowl								
16	LeBlanc 1990	Whiteface Mountain					320			
17	Leopold et al. 1988	Phelps Brook								
18	Maine Critical Areas Program 1983b	Basin Ponds					274-300+			
18	Maine Critical Areas Program 1983b	Bernard Mountain	150	200+			200+			
18	Maine Critical Areas Program 1983b	Cathedral Woods					165			
18	Maine Critical Areas Program 1983b	Crocker Mountain					200			

(Table 82 continued on next page)

(Table 82 continued)

Map Key	Source/Date	Stand	Average Tree Age (yr) Red Spruce	Average Tree Age (yr) Balsam Fir	Average Tree Age (yr) White Spruce	Average Tree Age (yr) Fraser Fir	Maximum Tree Age (yr) Red Spruce	Maximum Tree Age (yr) Balsam Fir	Maximum Tree Age (yr) White Spruce	Maximum Tree Age (yr) Fraser Fir
18	Maine Critical Areas Program 1983b	East Royce Mountain					250			
18	Maine Critical Areas Program 1983b	Elephant Mountain					300+	65		
18	Maine Critical Areas Program 1983b	Hurd Mountain					156			
18	Maine Critical Areas Program 1983b	Jonesborough					186			
18	Maine Critical Areas Program 1983b	Mooseleuk Mountain					125+[6]			
18	Maine Critical Areas Program 1983b	Nestuntabunt Mountain					145			
18	Maine Critical Areas Program 1983b	North Traveler	230				301+			
18	Maine Critical Areas Program 1983b	No. 9 Mountain	120-140[7]				138			
18	Maine Critical Areas Program 1983b	Priestly Mountain					234			
18	Maine Critical Areas Program 1983b	Roque Island	145				215+			
18	Maine Critical Areas Program 1983b	Sugarloaf-Burnt Hill Saddle					260	150		
18	Maine Critical Areas Program 1983b	T13 R11 Red Spruce					190			
18	Maine Critical Areas Program 1983b	Traveler Mountain					252	70		
18	Maine Critical Areas Program 1983b	Wassataquoik Lake					~250	98		
19	Maine State Planning Office 1986	Black Mountain	90-130							
19	Maine State Planning Office 1986	Center Mountain	340-390							
19	Maine State Planning Office 1986	Crater-Denny-Galilee	90-130							
19	Maine State Planning Office 1986	Deboullie Mountain	90-130							
19	Maine State Planning Office 1986	East Nubble Red Spruce	120-250							
19	Maine State Planning Office 1986	Gardner Mountain	90-130							
19	Maine State Planning Office 1986	Mahoosuc Mountain	245							
19	Maine State Planning Office 1986	Pushineer Pond	90-130							
19	Maine State Planning Office 1986	Wassataquiok Mountain	200-250							
20	McIntosh and Hurley 1964	Catskills--22 stands	118-160				320	114		
21	McMartin 1994	Big Moose Lake								
21	McMartin 1994	Powley--Red Spruce/Mixed Stand					300+			
21	McMartin 1994	Powley--Spruce Flat					285			
21	McMartin 1994	Stillwater Reservoir								
22	Oosting and Billings 1951	Great Smoky Mountains (9 stands)	200-250				359			
22	Oosting and Billings 1951	White Mountains (4 stands)	200-250				299			
23	Reiners and Lang 1979	Three areas in White Mountains		55				111		
24	Rheinhardt and Ware 1984	Balsam Mountains--Spruce								
24	Rheinhardt and Ware 1984	Balsam Mountains--Spruce-Fir								
25	Roman 1980	Adirondacks--Poor Fen								
25	Roman 1980	Adirondacks--Rich Fen								
25	Roman 1980	Adirondacks--Upland Mixed-red spruce								
26	Sprugel 1976	Whiteface Mountain--Esther/Lookout		1.2-79.0[8]				82		
27	Stephenson and Adams 1984	Mount Rogers--5 stands near summit	79[9]				168			123
27	Stephenson and Adams 1984	Mount Rogers--NE Slope	92[10]							
27	Stephenson and Adams 1984	Mount Rogers--NW Slope	67[10]							

(Table 82 continued on next page)

(Table 82 continued)

Map			Average Tree Age (yr)				Maximum Tree Age (yr)			
Key	Source/Date	Stand	Red Spruce	Balsam Fir	White Spruce	Fraser Fir	Red Spruce	Balsam Fir	White Spruce	Fraser Fir
27	Stephenson and Adams 1984	Mount Rogers--Ridgetop	60[10]							
27	Stephenson and Adams 1984	Mount Rogers--SE Slope	88[10]							
27	Stephenson and Adams 1984	Mount Rogers--SW Slope	83[10]							
28	Weaver 1972	Balsam Mountains					247			
29	White et al. 1985	Great Smoky Mountains--Mt. Collins					225[11]			137[11]

[1] Tree ages based on 11 red spruce.

[2] For explanation of community types see Table 77, Endnote 2.

[3] Average maximum age.

[4] Oldest tree found in entire Nehasane Park.

[5] Maximum age for yellow birch was 267 yr.

[6] Age estimate.

[7] Average maximum age.

[8] Average age of trees sampled at points along transects, depending on relative location of "wave".

[9] Average age of stand based on 7-10 cores per stand.

[10] Average age of stand based on 7-10 cores from larger trees of representative species.

[11] Maximum age is mean age at death for canopy gapmakers.

Table 83.—*Maximum tree diameter by species, and the percentage of the tree canopy in gaps, for montane and allied spruce-fir old-growth study sites.*

Map			----------Maximum Tree Diameter (cm)----------				Canopy
Key	**Source/Date**	**Stand**	**Red Spruce**	**Balsam Fir**	**Yellow Birch**	**Fraser Fir**	**Gaps (%)**
1	Adams and Stephenson 1989	Gaudineer Knob	60+				
1	Adams and Stephenson 1989	Salt Pond Mountain	60+				
1	Adams and Stephenson 1989	Shavers Mountain	60+				
1	Adams and Stephenson 1989	Turkey Run	50+				
2	Boner 1979	Great Smoky Mountains--<1830m	>84			>53	
2	Boner 1979	Great Smoky Mountains-->=1830m	>64			>53	
3	Carbonneau 1986a	Eagle Cliff--SF-3	<65	<45	<35		
3	Carbonneau 1986a	Gibbs Brook--SF-2	<65	<45	<35		
3	Carbonneau 1986a	Nancy Brook--SF-1	<65	<45	<35		
3	Carbonneau 1986a	Norton Pool--SF-4	<65	<45	<35		
4	Cogbill 1985	Big Reed Pond--Red Spruce-Fir					
4	Cogbill 1985	Big Reed Pond--Red Spruce-Mixed					
5	Cogbill 1996	Basin Ponds	46				
5	Cogbill 1996	Bernard Mountain	53				
5	Cogbill 1996	Big Reed	51				
5	Cogbill 1996	Dry Town	53				
5	Cogbill 1996	East Mountain	51				
5	Cogbill 1996	Elephant Mountain	53				
5	Cogbill 1996	Gill Brook	48				
5	Cogbill 1996	Lake Arnold	42				
5	Cogbill 1996	Nancy Brook	58				
5	Cogbill 1996	North Turner Brook	51				
5	Cogbill 1996	Norton Pool	46				
5	Cogbill 1996	Phelps Mountain	67				
5	Cogbill 1996	The Bowl	48				
5	Cogbill 1996	Wizard Pond	64				
6	Crandall 1958	Great Smoky Mountains (GSM)	96			74	
6	Crandall 1958	GSM--Fir Type-O-H T [1]					
6	Crandall 1958	GSM--Fir Type-O-D T					
6	Crandall 1958	GSM--Fir Type-Vi-Va-D T					
6	Crandall 1958	GSM--Fir Type-Se T					
6	Crandall 1958	GSM--Spruce-Fir Type-O-H T					
6	Crandall 1958	GSM--Spruce-Fir Type-H-Va T					
6	Crandall 1958	GSM--Spruce-Fir Type-Vi-Va-D T					
6	Crandall 1958	GSM--Spruce-Fir Type-Vi-Va-Se T					
6	Crandall 1958	GSM--Spruce-Fir Type-R T					
6	Crandall 1958	GSM--Spruce-Fir Type-R (Vi) T					
6	Crandall 1958	GSM--Spruce Type-H-Va T					
6	Crandall 1958	GSM--Spruce Type-Vi-Va-D T					
6	Crandall 1958	GSM--Spruce Type-Vi-Va-L T					

(Table 83 continued on next page)

(Table 83 continued)

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm): Red Spruce	Balsam Fir	Yellow Birch	Fraser Fir	Canopy Gaps (%)
6	Crandall 1958	GSM--Spruce Type-R T					
6	Crandall 1958	GSM--Spruce Type-R (Vi) T					
6	Crandall 1958	GSM--Spruce-Hardwood Type-Vi T					
6	Crandall 1958	GSM--Spruce-Hardwood Type-As T					
6	Crandall 1958	GSM--Spruce-Hardwood Type-R T					
7	Davis 1966	Ironbound Island					
7	Davis 1966	Otter Point	60+				
7	Davis 1966	Western Mountain	~46				
8	Fitzgerald and Raynal 1991	Whiteface Mountain--900 m					
8	Fitzgerald and Raynal 1991	Whiteface Mountain--1100 m					
9	Foster and Reiners 1983	Basin Ponds					
9	Foster and Reiners 1983	Bernard Mountain					
9	Foster and Reiners 1983	Gibbs Brook--825 m					24[2]
9	Foster and Reiners 1983	Gibbs Brook--890 m					24[2]
9	Foster and Reiners 1983	Gibbs Brook--955 m					24[2]
9	Foster and Reiners 1983	Gibbs Brook--1020 m					24[2]
9	Foster and Reiners 1983	North Traveler Mountain					
10	Graves 1899	Nehasane Park--spruce flats	69	46	86		
10	Graves 1899	Nehasane Park--spruce slopes	86	46	102		
10	Graves 1899	Nehasane Park--swamp lands	69	61	91		
11	Hosmer and Bruce 1901	Township 40--spruce lower slopes	89	61	107		
11	Hosmer and Bruce 1901	Township 40--swamp	81	46	74		
11	Hosmer and Bruce 1901	Township 40--upper spruce slopes	86	43	86		
12	Korstian 1937	Black Mountains	84+		64+	33+	
12	Korstian 1937	Pisgah Ridge	84+			53+	
12	Korstian 1937	Turkey Run	64+				
12	Korstian 1937	Unaka Mountain	84+				
13	Leak 1985b	Nancy Brook	56[3]	30[3]			
13	Leak 1985b	The Bowl	68[3]		73[3]		
14	Leak 1987b	Bartlett--Bedrock-500-550 m-1932					
14	Leak 1987b	Bartlett--Bedrock-500-550 m-1984					
14	Leak 1987b	Bartlett--Bedrock-650 m-1932					
14	Leak 1987b	Bartlett--Bedrock-650 m-1984					
15	Leak and Graber 1974	Mt. Whiteface/The Bowl	15-71[4]				
16	LeBlanc 1990	Whiteface Mountain	52				
17	Leopold et al. 1988	Phelps Brook					
18	Maine Critical Areas Program 1983b	Basin Ponds	46				
18	Maine Critical Areas Program 1983b	Bernard Mountain	53				
18	Maine Critical Areas Program 1983b	Cathedral Woods	46				
18	Maine Critical Areas Program 1983b	Crocker Mountain	49				

(Table 83 continued on next page)

(Table 83 continued)

			Maximum Tree Diameter (cm)				Canopy Gaps (%)
Map Key	Source/Date	Stand	Red Spruce	Balsam Fir	Yellow Birch	Fraser Fir	
18	Maine Critical Areas Program 1983b	East Royce Mountain	54				
18	Maine Critical Areas Program 1983b	Elephant Mountain	71				
18	Maine Critical Areas Program 1983b	Hurd Mountain	76				
18	Maine Critical Areas Program 1983b	Jonesborough	51				
18	Maine Critical Areas Program 1983b	Mooseleuk Mountain	56 [5]				
18	Maine Critical Areas Program 1983b	Nestuntabunt Mountain	56				
18	Maine Critical Areas Program 1983b	North Traveler	61	41			
18	Maine Critical Areas Program 1983b	No. 9 Mountain	41				
18	Maine Critical Areas Program 1983b	Priestly Mountain	61				
18	Maine Critical Areas Program 1983b	Roque Island					
18	Maine Critical Areas Program 1983b	Sugarloaf-Burnt Hill Saddle					
18	Maine Critical Areas Program 1983b	T13 R11 Red Spruce	55				
18	Maine Critical Areas Program 1983b	Traveler Mountain	64				
18	Maine Critical Areas Program 1983b	Wassataquoik Lake	71				
19	Maine State Planning Office 1986	Black Mountain					
19	Maine State Planning Office 1986	Center Mountain					
19	Maine State Planning Office 1986	Crater-Denny-Galilee					
19	Maine State Planning Office 1986	Deboullie Mountain					
19	Maine State Planning Office 1986	East Nubble Red Spruce					
19	Maine State Planning Office 1986	Gardner Mountain					
19	Maine State Planning Office 1986	Mahoosuc Mountain					
19	Maine State Planning Office 1986	Pushineer Pond					
19	Maine State Planning Office 1986	Wassataquiok Mountain					
20	McIntosh and Hurley 1964	Catskills--22 stands	53	25			
21	McMartin 1994	Big Moose Lake	66				
21	McMartin 1994	Powley--Red Spruce/Mixed Stand	86 [6]				
21	McMartin 1994	Powley--Spruce Flat	91 [7]				
21	McMartin 1994	Stillwater Reservoir	69				
22	Oosting and Billings 1951	Great Smoky Mountains (9 stands)					
22	Oosting and Billings 1951	White Mountains (4 stands)					
23	Reiners and Lang 1979	Three areas in White Mountains					
24	Rheinhardt and Ware 1984	Balsam Mountains--Spruce					
24	Rheinhardt and Ware 1984	Balsam Mountains--Spruce-Fir					
25	Roman 1980	Adirondacks--Poor Fen					
25	Roman 1980	Adirondacks--Rich Fen					
25	Roman 1980	Adirondacks--Upland Mixed-red spruce					
26	Sprugel 1976	Whiteface Mountain--Esther/Lookout					20-30 [8]
27	Stephenson and Adams 1984	Mount Rogers--5 stands near summit	46			54	
27	Stephenson and Adams 1984	Mount Rogers--NE Slope					
27	Stephenson and Adams 1984	Mount Rogers--NW Slope					

(Table 83 continued on next page)

(Table 83 continued)

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm)				Canopy Gaps (%)
			Red Spruce	Balsam Fir	Yellow Birch	Fraser Fir	
27	Stephenson and Adams 1984	Mount Rogers--Ridgetop					
27	Stephenson and Adams 1984	Mount Rogers--SE Slope					
27	Stephenson and Adams 1984	Mount Rogers--SW Slope					
28	Weaver 1972	Balsam Mountains	48				
29	White et al. 1985	Great Smoky Mountains--Mt. Collins	100			~40	17 [9]

[1] For explanation of community types see Table 77, Endnote 2.

[2] Percentage of canopy in gaps is 24%; including wave-regeneration sequences, percentage of disturbance-created patches is 39%.

[3] Diameters given are diameter at top of root swell, not d.b.h.

[4] Range reflects maximum diameter of red spruce at different elevations (71 at 700 m, 68.6 at 800 m, 64.5 at 900 m, 59.7 at 1000 m, 34.4 at 1100 m, and 14.7 at 1200 m).

[5] Diameter smaller at higher elevation.

[6] Average red spruce size = 35.6 cm.

[7] Average red spruce size = 45.5 cm.

[8] Gap percentage describes wave zones along transects.

[9] Gap percentage for gaps ≥10 yr old.

Table 84.—*Density, basal area, and minimum diameter measured for standing dead trees (snags) for montane and allied spruce-fir old-growth study sites.*

			Standing Dead Trees (Snags)		
Map Key	**Source/Date**	**Stand**	**Snag Density (#/ha)**	**Snag Basal Area (m^2/ha)**	**Min Snag Diam (cm)**
1	Adams and Stephenson 1989	Gaudineer Knob	390 [1,2]		2.5
1	Adams and Stephenson 1989	Salt Pond Mountain			
1	Adams and Stephenson 1989	Shavers Mountain	40 [1,3]		2.5
1	Adams and Stephenson 1989	Turkey Run	165 [1,4]		2.5
2	Boner 1979	Great Smoky Mountains--<1830m			
2	Boner 1979	Great Smoky Mountains-->=1830m			
3	Carbonneau 1986a	Eagle Cliff--SF-3	183	9.1	10
3	Carbonneau 1986a	Gibbs Brook--SF-2	44		10
3	Carbonneau 1986a	Nancy Brook--SF-1	280	13.9	10
3	Carbonneau 1986a	Norton Pool--SF-4	592	23.0	10
4	Cogbill 1985	Big Reed Pond--Red Spruce-Fir		6.2	10
4	Cogbill 1985	Big Reed Pond--Red Spruce-Mixed		3.7	10
5	Cogbill 1996	Basin Ponds			
5	Cogbill 1996	Bernard Mountain			
5	Cogbill 1996	Big Reed			
5	Cogbill 1996	Dry Town			
5	Cogbill 1996	East Mountain			
5	Cogbill 1996	Elephant Mountain			
5	Cogbill 1996	Gill Brook			
5	Cogbill 1996	Lake Arnold			
5	Cogbill 1996	Nancy Brook			
5	Cogbill 1996	North Turner Brook			
5	Cogbill 1996	Norton Pool			
5	Cogbill 1996	Phelps Mountain			
5	Cogbill 1996	The Bowl			
5	Cogbill 1996	Wizard Pond			
6	Crandall 1958	Great Smoky Mountains (GSM)			
6	Crandall 1958	GSM--Fir Type-O-H T [5]			
6	Crandall 1958	GSM--Fir Type-O-D T			
6	Crandall 1958	GSM--Fir Type-Vi-Va-D T			
6	Crandall 1958	GSM--Fir Type-Se T			
6	Crandall 1958	GSM--Spruce-Fir Type-O-H T			
6	Crandall 1958	GSM--Spruce-Fir Type-H-Va T			
6	Crandall 1958	GSM--Spruce-Fir Type-Vi-Va-D T			
6	Crandall 1958	GSM--Spruce-Fir Type-Vi-Va-Se T			
6	Crandall 1958	GSM--Spruce-Fir Type-R T			
6	Crandall 1958	GSM--Spruce-Fir Type-R (Vi) T			
6	Crandall 1958	GSM--Spruce Type-H-Va T			
6	Crandall 1958	GSM--Spruce Type-Vi-Va-D T			
6	Crandall 1958	GSM--Spruce Type-Vi-Va-L T			

(Table 84 continued on next page)

(Table 84 continued)

Map Key	Source/Date	Stand	Standing Dead Trees (Snags)		
			Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Min Snag Diam (cm)
6	Crandall 1958	GSM--Spruce Type-R T			
6	Crandall 1958	GSM--Spruce Type-R (Vi) T			
6	Crandall 1958	GSM--Spruce-Hardwood Type-Vi T			
6	Crandall 1958	GSM--Spruce-Hardwood Type-As T			
6	Crandall 1958	GSM--Spruce-Hardwood Type-R T			
7	Davis 1966	Ironbound Island			
7	Davis 1966	Otter Point			
7	Davis 1966	Western Mountain			
8	Fitzgerald and Raynal 1991	Whiteface Mountain--900 m			
8	Fitzgerald and Raynal 1991	Whiteface Mountain--1100 m			
9	Foster and Reiners 1983	Basin Ponds			
9	Foster and Reiners 1983	Bernard Mountain			
9	Foster and Reiners 1983	Gibbs Brook--825 m	36	3.1	20
9	Foster and Reiners 1983	Gibbs Brook--890 m	80	11	20
9	Foster and Reiners 1983	Gibbs Brook--955 m	160	12.3	20
9	Foster and Reiners 1983	Gibbs Brook--1020 m	167	10.2	20
9	Foster and Reiners 1983	North Traveler Mountain			
10	Graves 1899	Nehasane Park--spruce flats			
10	Graves 1899	Nehasane Park--spruce slopes			
10	Graves 1899	Nehasane Park--swamp lands			
11	Hosmer and Bruce 1901	Township 40--spruce lower slopes			
11	Hosmer and Bruce 1901	Township 40--swamp			
11	Hosmer and Bruce 1901	Township 40--upper spruce slopes			
12	Korstian 1937	Black Mountains			
12	Korstian 1937	Pisgah Ridge			
12	Korstian 1937	Turkey Run			
12	Korstian 1937	Unaka Mountain			
13	Leak 1985b	Nancy Brook			
13	Leak 1985b	The Bowl			
14	Leak 1987b	Bartlett--Bedrock-500-550 m-1932			
14	Leak 1987b	Bartlett--Bedrock-500-550 m-1984			
14	Leak 1987b	Bartlett--Bedrock-650 m-1932			
14	Leak 1987b	Bartlett--Bedrock-650 m-1984			
15	Leak and Graber 1974	Mt. Whiteface/The Bowl			
16	LeBlanc 1990	Whiteface Mountain			
17	Leopold et al. 1988	Phelps Brook	392	16.3	5
18	Maine Critical Areas Program 1983b	Basin Ponds			
18	Maine Critical Areas Program 1983b	Bernard Mountain			
18	Maine Critical Areas Program 1983b	Cathedral Woods			
18	Maine Critical Areas Program 1983b	Crocker Mountain			

(Table 84 continued on next page)

(Table 84 continued)

			Standing Dead Trees (Snags)		
Map Key	Source/Date	Stand	Snag Density (#/ha)	Snag Basal Area (m^2/ha)	Min Snag Diam (cm)
18	Maine Critical Areas Program 1983b	East Royce Mountain			
18	Maine Critical Areas Program 1983b	Elephant Mountain			
18	Maine Critical Areas Program 1983b	Hurd Mountain			
18	Maine Critical Areas Program 1983b	Jonesborough			
18	Maine Critical Areas Program 1983b	Mooseleuk Mountain			
18	Maine Critical Areas Program 1983b	Nestuntabunt Mountain			
18	Maine Critical Areas Program 1983b	North Traveler			
18	Maine Critical Areas Program 1983b	No. 9 Mountain			
18	Maine Critical Areas Program 1983b	Priestly Mountain			
18	Maine Critical Areas Program 1983b	Roque Island			
18	Maine Critical Areas Program 1983b	Sugarloaf-Burnt Hill Saddle			
18	Maine Critical Areas Program 1983b	T13 R11 Red Spruce			
18	Maine Critical Areas Program 1983b	Traveler Mountain			
18	Maine Critical Areas Program 1983b	Wassataquoik Lake			
19	Maine State Planning Office 1986	Black Mountain			
19	Maine State Planning Office 1986	Center Mountain			
19	Maine State Planning Office 1986	Crater-Denny-Galilee			
19	Maine State Planning Office 1986	Deboullie Mountain			
19	Maine State Planning Office 1986	East Nubble Red Spruce			
19	Maine State Planning Office 1986	Gardner Mountain			
19	Maine State Planning Office 1986	Mahoosuc Mountain			
19	Maine State Planning Office 1986	Pushineer Pond			
19	Maine State Planning Office 1986	Wassataquiok Mountain			
20	McIntosh and Hurley 1964	Catskills--22 stands			
21	McMartin 1994	Big Moose Lake			
21	McMartin 1994	Powley--Red Spruce/Mixed Stand			
21	McMartin 1994	Powley--Spruce Flat			
21	McMartin 1994	Stillwater Reservoir			
22	Oosting and Billings 1951	Great Smoky Mountains (9 stands)			
22	Oosting and Billings 1951	White Mountains (4 stands)			
23	Reiners and Lang 1979	Three areas in White Mountains	1100	8.6[6]	5
24	Rheinhardt and Ware 1984	Balsam Mountains--Spruce			
24	Rheinhardt and Ware 1984	Balsam Mountains--Spruce-Fir			
25	Roman 1980	Adirondacks--Poor Fen			
25	Roman 1980	Adirondacks--Rich Fen			
25	Roman 1980	Adirondacks--Upland Mixed-red spruce			
26	Sprugel 1976	Whiteface Mountain--Esther/Lookout			
27	Stephenson and Adams 1984	Mount Rogers--5 stands near summit			
27	Stephenson and Adams 1984	Mount Rogers--NE Slope			
27	Stephenson and Adams 1984	Mount Rogers--NW Slope			

(Table 84 continued on next page)

(Table 84 continued)

			Standing Dead Trees (Snags)		
Map Key	**Source/Date**	**Stand**	**Snag Density (#/ha)**	**Snag Basal Area (m^2/ha)**	**Min Snag Diam (cm)**
27	Stephenson and Adams 1984	Mount Rogers--Ridgetop			
27	Stephenson and Adams 1984	Mount Rogers--SE Slope			
27	Stephenson and Adams 1984	Mount Rogers--SW Slope			
28	Weaver 1972	Balsam Mountains			
29	White et al. 1985	Great Smoky Mountains--Mt. Collins			

[1] Density of snags is for red spruce only.

[2] 43% of all red spruce stems were dead.

[3] 15% of all red spruce stems were dead.

[4] 37% of all red spruce stems were dead. Severe red spruce growth decline since 1960.

[5] For explanation of community types see Table 77, Endnote 2.

[6] Basal area for snags >2m tall.

Table 85.—*Density, volume, and minimum diameter measured for fallen dead trees (logs) for montane and allied spruce-fir old-growth study sites.*

			Fallen Dead Trees (Logs)		
Map Key	**Source/Date**	**Stand**	**Density of Logs (#/ha)**	**Volume of Logs (m^3/ha)**	**Min Diam Logs (cm)**
1	Adams and Stephenson 1989	Gaudineer Knob			
1	Adams and Stephenson 1989	Salt Pond Mountain			
1	Adams and Stephenson 1989	Shavers Mountain			
1	Adams and Stephenson 1989	Turkey Run			
2	Boner 1979	Great Smoky Mountains--<1830m			
2	Boner 1979	Great Smoky Mountains-->=1830m			
3	Carbonneau 1986a	Eagle Cliff--SF-3	183		10
3	Carbonneau 1986a	Gibbs Brook--SF-2	356	691	10
3	Carbonneau 1986a	Nancy Brook--SF-1	467	951	10
3	Carbonneau 1986a	Norton Pool--SF-4	325	716	10
4	Cogbill 1985	Big Reed Pond--Red Spruce-Fir			
4	Cogbill 1985	Big Reed Pond--Red Spruce-Mixed			
5	Cogbill 1996	Basin Ponds			
5	Cogbill 1996	Bernard Mountain			
5	Cogbill 1996	Big Reed			
5	Cogbill 1996	Dry Town			
5	Cogbill 1996	East Mountain			
5	Cogbill 1996	Elephant Mountain			
5	Cogbill 1996	Gill Brook			
5	Cogbill 1996	Lake Arnold			
5	Cogbill 1996	Nancy Brook			
5	Cogbill 1996	North Turner Brook			
5	Cogbill 1996	Norton Pool			
5	Cogbill 1996	Phelps Mountain			
5	Cogbill 1996	The Bowl			
5	Cogbill 1996	Wizard Pond			
6	Crandall 1958	Great Smoky Mountains (GSM)			
6	Crandall 1958	GSM--Fir Type-O-H T [1]			
6	Crandall 1958	GSM--Fir Type-O-D T			
6	Crandall 1958	GSM--Fir Type-Vi-Va-D T			
6	Crandall 1958	GSM--Fir Type-Se T			
6	Crandall 1958	GSM--Spruce-Fir Type-O-H T			
6	Crandall 1958	GSM--Spruce-Fir Type-H-Va T			
6	Crandall 1958	GSM--Spruce-Fir Type-Vi-Va-D T			
6	Crandall 1958	GSM--Spruce-Fir Type-Vi-Va-Se T			
6	Crandall 1958	GSM--Spruce-Fir Type-R T			
6	Crandall 1958	GSM--Spruce-Fir Type-R (Vi) T			
6	Crandall 1958	GSM--Spruce Type-H-Va T			
6	Crandall 1958	GSM--Spruce Type-Vi-Va-D T			
6	Crandall 1958	GSM--Spruce Type-Vi-Va-L T			

(Table 85 continued on next page)

(Table 85 continued)

			Fallen Dead Trees (Logs)		
Map Key	Source/Date	Stand	Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)
6	Crandall 1958	GSM--Spruce Type-R T			
6	Crandall 1958	GSM--Spruce Type-R (Vi) T			
6	Crandall 1958	GSM--Spruce-Hardwood Type-Vi T			
6	Crandall 1958	GSM--Spruce-Hardwood Type-As T			
6	Crandall 1958	GSM--Spruce-Hardwood Type-R T			
7	Davis 1966	Ironbound Island			
7	Davis 1966	Otter Point			
7	Davis 1966	Western Mountain			
8	Fitzgerald and Raynal 1991	Whiteface Mountain--900 m			
8	Fitzgerald and Raynal 1991	Whiteface Mountain--1100 m			
9	Foster and Reiners 1983	Basin Ponds			
9	Foster and Reiners 1983	Bernard Mountain			
9	Foster and Reiners 1983	Gibbs Brook--825 m			
9	Foster and Reiners 1983	Gibbs Brook--890 m			
9	Foster and Reiners 1983	Gibbs Brook--955 m			
9	Foster and Reiners 1983	Gibbs Brook--1020 m			
9	Foster and Reiners 1983	North Traveler Mountain			
10	Graves 1899	Nehasane Park--spruce flats			
10	Graves 1899	Nehasane Park--spruce slopes			
10	Graves 1899	Nehasane Park--swamp lands			
11	Hosmer and Bruce 1901	Township 40--spruce lower slopes			
11	Hosmer and Bruce 1901	Township 40--swamp			
11	Hosmer and Bruce 1901	Township 40--upper spruce slopes			
12	Korstian 1937	Black Mountains			
12	Korstian 1937	Pisgah Ridge			
12	Korstian 1937	Turkey Run			
12	Korstian 1937	Unaka Mountain			
13	Leak 1985b	Nancy Brook			
13	Leak 1985b	The Bowl			
14	Leak 1987b	Bartlett--Bedrock-500-550 m-1932			
14	Leak 1987b	Bartlett--Bedrock-500-550 m-1984			
14	Leak 1987b	Bartlett--Bedrock-650 m-1932			
14	Leak 1987b	Bartlett--Bedrock-650 m-1984			
15	Leak and Graber 1974	Mt. Whiteface/The Bowl			
16	LeBlanc 1990	Whiteface Mountain			
17	Leopold et al. 1988	Phelps Brook			
18	Maine Critical Areas Program 1983b	Basin Ponds			
18	Maine Critical Areas Program 1983b	Bernard Mountain			
18	Maine Critical Areas Program 1983b	Cathedral Woods			
18	Maine Critical Areas Program 1983b	Crocker Mountain			

(Table 85 continued on next page)

(Table 85 continued)

			Fallen Dead Trees (Logs)		
Map Key	Source/Date	Stand	Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)
18	Maine Critical Areas Program 1983b	East Royce Mountain			
18	Maine Critical Areas Program 1983b	Elephant Mountain			
18	Maine Critical Areas Program 1983b	Hurd Mountain			
18	Maine Critical Areas Program 1983b	Jonesborough			
18	Maine Critical Areas Program 1983b	Mooseleuk Mountain			
18	Maine Critical Areas Program 1983b	Nestuntabunt Mountain			
18	Maine Critical Areas Program 1983b	North Traveler			
18	Maine Critical Areas Program 1983b	No. 9 Mountain			
18	Maine Critical Areas Program 1983b	Priestly Mountain			
18	Maine Critical Areas Program 1983b	Roque Island			
18	Maine Critical Areas Program 1983b	Sugarloaf-Burnt Hill Saddle			
18	Maine Critical Areas Program 1983b	T13 R11 Red Spruce			
18	Maine Critical Areas Program 1983b	Traveler Mountain			
18	Maine Critical Areas Program 1983b	Wassataquoik Lake			
19	Maine State Planning Office 1986	Black Mountain			
19	Maine State Planning Office 1986	Center Mountain			
19	Maine State Planning Office 1986	Crater-Denny-Galilee			
19	Maine State Planning Office 1986	Deboullie Mountain			
19	Maine State Planning Office 1986	East Nubble Red Spruce			
19	Maine State Planning Office 1986	Gardner Mountain			
19	Maine State Planning Office 1986	Mahoosuc Mountain			
19	Maine State Planning Office 1986	Pushineer Pond			
19	Maine State Planning Office 1986	Wassataquiok Mountain			
20	McIntosh and Hurley 1964	Catskills--22 stands			
21	McMartin 1994	Big Moose Lake			
21	McMartin 1994	Powley--Red Spruce/Mixed Stand			
21	McMartin 1994	Powley--Spruce Flat			
21	McMartin 1994	Stillwater Reservoir			
22	Oosting and Billings 1951	Great Smoky Mountains (9 stands)			
22	Oosting and Billings 1951	White Mountains (4 stands)			
23	Reiners and Lang 1979	Three areas in White Mountains			
24	Rheinhardt and Ware 1984	Balsam Mountains--Spruce			
24	Rheinhardt and Ware 1984	Balsam Mountains--Spruce-Fir			
25	Roman 1980	Adirondacks--Poor Fen			
25	Roman 1980	Adirondacks--Rich Fen			
25	Roman 1980	Adirondacks--Upland Mixed-red spruce			
26	Sprugel 1976	Whiteface Mountain--Esther/Lookout			
27	Stephenson and Adams 1984	Mount Rogers--5 stands near summit			
27	Stephenson and Adams 1984	Mount Rogers--NE Slope			
27	Stephenson and Adams 1984	Mount Rogers--NW Slope			

(Table 85 continued on next page)

(Table 85 continued)

Map Key	Source/Date	Stand	Fallen Dead Trees (Logs) Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)
27	Stephenson and Adams 1984	Mount Rogers--Ridgetop			
27	Stephenson and Adams 1984	Mount Rogers--SE Slope			
27	Stephenson and Adams 1984	Mount Rogers--SW Slope			
28	Weaver 1972	Balsam Mountains			
29	White et al. 1985	Great Smoky Mountains--Mt. Collins			

[1] For explanation of community types see Table 77, Endnote 2.

Table 86.—*Summary of attributes for old-growth montane and allied spruce-fir stands (from Table 77 through 85).*

Attribute	Range	References (Map Key)
Live Tree Density (#/ha)		
- Trees ≥ 2.5 cm d.b.h.	855 - 3310	1, 9, 22
- Trees ≥ 10 cm d.b.h.	385 - 1750	1, 3, 7, 12, 18, 25, 27
- Trees ≥ 12.7 cm d.b.h.	692 - 876	2
- Trees ≥ 20 cm d.b.h.	210 - 594	5, 9
- Trees ≥ 50 cm d.b.h.	20 - 45	1
- Trees ≥ 70 cm d.b.h.	0 - 20	1
- Not as specified above		10, 11, 12, 17, 23, 27, 28, 29
Live Tree Basal Area (m^2/ha)		
- Trees ≥ 2.5 cm d.b.h.	35.3 - 58.7	1, 9, 22
- Trees ≥ 10 cm d.b.h.	13.8 - 63.3	1, 3, 7, 12, 18, 25, 27
- Trees ≥ 12.7 cm d.b.h.	27.5 - 84.5	2, 6
- Trees ≥ 20 cm d.b.h.	22 - 49.5	5, 9
- Trees ≥ 50 cm d.b.h.	--	--
- Trees ≥ 70 cm d.b.h.	--	--
- Not as specified above		8, 14, 17, 23, 24, 28
Tree or Stand Age (yr)		
Average Age by Species		
- Red Spruce	20 - 390	1, 4, 5, 7, 18, 19, 20, 22, 27
- Balsam Fir	1.2 - 200	8, 18, 23, 26
Maximum Age by Species		
- Red Spruce	125 - 423	1, 4, 5, 7, 9, 10, 13, 16, 18, 20, 21, 22, 27, 28, 29
- Balsam Fir	65 - 202	8, 13, 18, 20, 23, 26
- White Spruce	125	7
- Fraser Fir	123 - 137	27, 29
Maximum Tree Diameter at Breast Height by Species (cm)		
- Red Spruce	15 - 100	1, 2, 3, 5, 6, 7, 10, 11, 12, 13, 15, 16, 18, 20, 21, 27, 28, 29
- Balsam Fir	25 - 61	3, 10, 11, 13, 18, 20
- Yellow Birch	<35 - 107	3, 10, 11, 12, 13
- Fraser Fir	33+ - 74	2, 6, 12, 27, 29

(Table 86 continued on next page)

(Table 86 continued)

Attribute	Range	References (Map Key)
Canopy Gaps (%)	20 - 30	9, 27
Standing Dead Trees (Snags)		
Snag Density (#/ha)		
- Snags ≥ 2.5 cm d.b.h.	40 - 390	1
- Snags ≥ 10 cm d.b.h.	44 - 592	3
- Snags ≥ 20 cm d.b.h.	36 - 167	9
- Not as specified above		17, 23
Snag Basal Area (m^2/ha)		
- Snags ≥ 10 cm d.b.h.	3.7 - 23.0	3, 4
- Snags ≥ 20 cm d.b.h.	3.1 - 12.3	9
- Not as specified above		17, 23
Fallen Dead Trees (Logs)		
Density of Logs (#/ha)		
- Logs ≥ 10 cm d.b.h.	183 - 467	3
Volume of Logs (m^3/ha)		
- Logs ≥ 10 cm d.b.h.	691 - 951	3

SUBBOREAL SPRUCE-FIR FORESTS

COMMUNITY COMPOSITION

Forest Cover Types

The following Society of American Foresters (SAF) forest cover types (Eyre 1980) are included in the subboreal spruce-fir forest type group:

5 - balsam fir
12 - black spruce (subtypes a, b, c)
107 - white spruce

The following Combined Data Systems (CDS) forest cover types for the USDA Forest Service Eastern Region (USDA 1974) are included in the subboreal spruce-fir forest type group:

11 - balsam fir/aspen/paper birch
12 - black spruce
17 - upland black spruce

Species Composition

White spruce (*Picea glauca* [Moench] Voss.), black spruce (*Picea mariana* [Mill.] B.S.P.), and balsam fir (*Abies balsamea* [L.] Mill.) are the predominant trees comprising subboreal forests. Common associates include paper birch (*Betula papyrifera* Marsh.), quaking aspen (*Populus tremuloides* Michx.), balsam poplar (*P. balsamifera* L.), eastern white pine (*Pinus strobus* L.), northern white-cedar (*Thuja occidentalis* L.), and eastern hemlock (*Tsuga canadensis* [L.] Carr.). Red spruce (*Picea rubens* Sarg.) is also an associate, but only in the northeast United States.

PHYSICAL CONTEXT

Physiographic Provinces

Subboreal spruce and spruce-fir forests occur in the following physiographic provinces (after Fenneman 1938):

New England	(all sections)
Adirondack	
Central Lowlands	(Great Lake and Western Young Drift sections)
Superior Upland	

▲ ***Port Wing Boreal Forest State Natural Area*** *in northern Wisconsin includes balsam fir, spruce, and paper birch. Photo 7/97 by Lucy Tyrrell.*

▲ ***High Lake State Natural Area**, a subboreal forest, is located in Vilas County, Wisconsin. Photo 5/95 by Lucy Tyrrell.*

Ecological Units

Subboreal spruce-fir forests occur in several divisions and provinces (see Keys *et al.* 1995):

200 Humid Temperate Domain
210 Warm Continental Division
212 Laurentian Mixed Forest Province
M210 Warm Continental Regime Mountains
M212 Adirondack-New England Mixed Forest-Coniferous Forest-Alpine Meadow Province

Geographic Distribution

Subboreal spruce-fir forests are present only in the coldest portions of the Upper Great Lakes (Minnesota through Michigan) and New England (northeastern Pennsylvania through Maine). These forests are commonly found along the Great Lakes where cold, upwelling water keeps summertime temperatures very cool. The southern extent of its range closely follows the distribution of white spruce. Subboreal spruce-fir stands of the eastern United States represent the southern-most extension of a large, contiguous forest that covers most of Canada.

Soils

These forests exist on myriad upland sites, from rock outcrops to deep, glacial tills. Depending on soil conditions and topographic position, sites can range from dry-mesic to wet-mesic. Soils are typically Spodosols or Inceptisols. The frost-free season is usually short, and much of the precipitation is snow.

DISTURBANCE

Disturbances are frequent, and many are catastrophic, affecting large areas. In New England, major disturbances are caused by windthrow (*e.g.*, hurricanes) or insect outbreaks (*e.g.*, spruce budworm). In the Upper Great Lakes Region, fire is a major disturbance in addition to windthrow and insect outbreaks.

RELATION TO OTHER FOREST TYPES

A transitional zone exists between subboreal spruce-fir forests and montane spruce-fir forests in New England. In this region, subboreal forests are restricted to low elevations (*e.g.*, valleys, mountain toeslopes) where temperatures are cold enough to support true boreal species, whereas montane forests generally occur on middle and upper slopes. The presence of white spruce, black spruce, and other boreal species are good indicators of subboreal forests in New England.

STRUCTURAL CHARACTERISTICS OF OLD-GROWTH STANDS

Information about subboreal spruce-fir forests in an old-growth condition is included in Figure 12 and Tables 87 through 96.

SELECTED REPRESENTATIVE OLD-GROWTH STANDS

Iowa

Bluffton Fir Stand, Winneshiek Co.

Michigan

North Fox Island*, Leelanau Co.

Minnesota

Boundary Waters Canoe Area Wilderness*, Superior National Forest

Red Lake Peatland*, Beltrami Island/Pine Island State Forest

Pennsylvania

Hickory Run State Park, Carbon Co.

Wisconsin

Flambeau River Preserve*, northern Wisconsin

High Lake State Natural Area, Vilas Co.

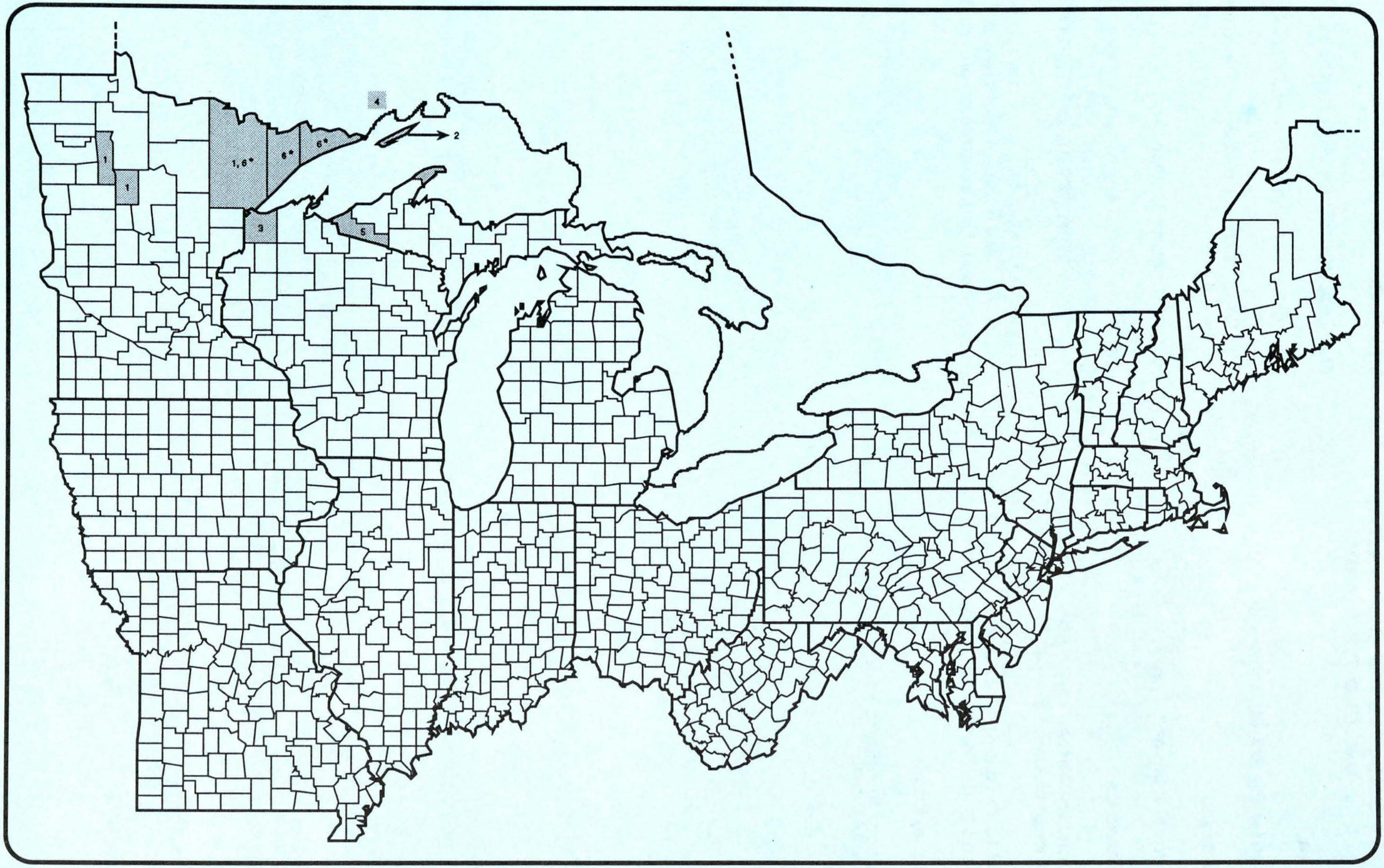
Port Wing Boreal Forest State Natural Area, Bayfield Co.

Ridges Sanctuary, Door Co.

Toft Point State Natural Area*, Door Co.

FOR ADDITIONAL INFORMATION

Additional references that pertain to subboreal spruce-fir forests but are not cited in tables or text are listed by forest type group in Appendix C.


4
2
1
1, 6*
6*
6*
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3
5

Figure 12.—*General location of studies that provide stand structure information about old-growth subboreal spruce-fir forests. Shaded counties contain at least one study. Numbers correspond to the cited references listed under Map Key below and in Tables 87 through 96. States are indicated using two-letter postal abbreviations. An asterisk indicates that the county is probable but not certain. The latitude and longitude of the Canadian study site are bracketed to indicate that these values were estimated from the location information provided by the authors in the cited study and used to plot the location of the shaded block on the map.*

Map Key	Source/Date	State or Province	County	Map Key	Source/Date	State or Province	County
1	Buell and Niering 1957	MN	Clearwater, Hubbard, St. Louis	4	Hett and Loucks 1976	Ontario	[48°30'N, 89°30'W]
2	Cooper 1913 a, b	MI	Keewenaw	5	Jones and Zicker 1955	MI	Gogebic
3	Fassett 1944	WI	Douglas	6	Ohmann and Ream 1971b	MN	Cook*, Lake*, St. Louis*

Table 87.—*Location, size, and elevation of subboreal spruce-fir old-growth study sites. Asterisks indicate that the Ohmann and Ream (1971) study took place in these three counties, but they did not specify for each forest type whether all three counties were involved.*

Map Key	Source/Date	Stand	State or Province	County or Latitude/Longitude	Size (ha)	Elevation (m)
1	Buell and Niering 1957	Iron Spring	MN	Clearwater	unspecified	unspecified
1	Buell and Niering 1957	Lake Alice	MN	Hubbard	unspecified	unspecified
1	Buell and Niering 1957	Moose River	MN	St. Louis	unspecified	unspecified
1	Buell and Niering 1957	Norway Island	MN	St. Louis	unspecified	unspecified
1	Buell and Niering 1957	Wilderness Center	MN	St. Louis	unspecified	unspecified
2	Cooper 1913 a, b	Isle Royale	MI	Keewenaw	unspecified	unspecified
3	Fassett 1944	Brule River Basin	WI	Douglas	unspecified	unspecified
4	Hett and Loucks 1976	Thunder Bay--Stand 1	Ontario	48°30'N, 89°30'W	unspecified	unspecified
4	Hett and Loucks 1976	Thunder Bay--Stand 2	Ontario	48°30'N, 89°30'W	unspecified	unspecified
4	Hett and Loucks 1976	Thunder Bay--Stand 3	Ontario	48°30'N, 89°30'W	unspecified	unspecified
5	Jones and Zicker 1955	Rahr Estate	MI	Gogebic	unspecified	unspecified
6	Ohmann and Ream 1971b	Boundary Waters--black spruce-jack pine	MN	St. Louis*, Lake*, Cook*	} 405,000 [1]	} 341-680 [1]
6	Ohmann and Ream 1971b	Boundary Waters--fir-birch	MN	St. Louis*, Lake*, Cook*	} [1]	} [1]

[1] Area and elevation for entire Boundary Waters Area.

Table 88.—*Criteria used by sources to identify old-growth stands, and information about stand composition of subboreal spruce-fir old-growth study sites.*

Map Key	Source/Date	Stand	Criteria for Stand Selection and Stand Composition
1	Buell and Niering 1957	Iron Spring	Long established stand; balsam fir-black spruce-white spruce-paper birch [1]
1	Buell and Niering 1957	Lake Alice	Long established stand; balsam fir-white spruce [1]
1	Buell and Niering 1957	Moose River	Long established stand; balsam fir-black spruce-white spruce-paper birch-jack pine [1]
1	Buell and Niering 1957	Norway Island	Long established stand; balsam fir-paper birch [1]
1	Buell and Niering 1957	Wilderness Center	Long established stand; balsam fir-paper birch [1]
2	Cooper 1913 a, b	Isle Royale	Study of climax forest, natural disturbance (wind), and balsam-birch-spruce forest
3	Fassett 1944	Brule River Basin	Presettlement forests of Brule River basin
4	Hett and Loucks 1976	Thunder Bay--Stand 1	Upland sites, with complete size class range, spruce 200+ yr
4	Hett and Loucks 1976	Thunder Bay--Stand 2	Upland sites, with complete size class range, spruce 200+ yr
4	Hett and Loucks 1976	Thunder Bay--Stand 3	Upland sites, with complete size class range, spruce 200+ yr
5	Jones and Zicker 1955	Rahr Estate	Small stand protected from cutting; white spruce (51%)-balsam fir (18%)-paper birch (14%)
6	Ohmann and Ream 1971b	Boundary Waters--black spruce-jack pine	Virgin plant community; black spruce-jack pine-balsam fir-paper birch
6	Ohmann and Ream 1971b	Boundary Waters--fir-birch	Virgin plant community; balsam fir-paper birch-black spruce-white cedar

[1] Stand had evidence of a previous pine component.

Table 89.—*Methods used to study old-growth subboreal spruce-fir (condensed from the cited references).*

Map Key	Source/Date	Stand	Sampling Methods
1	Buell and Niering 1957	Iron Spring	30 10 m x 10 m plots
1	Buell and Niering 1957	Lake Alice	6 10 m x 10 m plots
1	Buell and Niering 1957	Moose River	13 10 m x 10 m plots
1	Buell and Niering 1957	Norway Island	8 10 m x 10 m plots
1	Buell and Niering 1957	Wilderness Center	6 10 m x 10 m plots
2	Cooper 1913 a, b	Isle Royale	6 10 m x 10 m quadrats
3	Fassett 1944	Brule River Basin	Survey notes
4	Hett and Loucks 1976	Thunder Bay--Stand 1	Several "cells" 15.2 m x 15.2 m, or 20 m x 20 m
4	Hett and Loucks 1976	Thunder Bay--Stand 2	Several "cells" 15.2 m x 15.2 m, or 20 m x 20 m
4	Hett and Loucks 1976	Thunder Bay--Stand 3	Several "cells" 15.2 m x 15.2 m, or 20 m x 20 m
5	Jones and Zicker 1955	Rahr Estate	Random pairs, 5 trees at each of 20 points
6	Ohmann and Ream 1971b	Boundary Waters--black spruce-jack pine	20 plotless points per stand, random selection of stands
6	Ohmann and Ream 1971b	Boundary Waters--fir-birch	20 plotless points per stand, random selection of stands

Table 90.—*Density of live trees ≥10, ≥50, and ≥70 cm for subboreal spruce-fir study sites. For other minimum sizes, the density is listed under "≥X cm", with the minimum size for tallying trees given as "Min Diam X (cm)".*

			Live Tree Density				
Map Key	**Source/Date**	**Stand**	**≥10 cm (#/ha)**	**≥50 cm (#/ha)**	**≥70 cm (#/ha)**	**≥X cm (#/ha)**	**Min Diam X (cm)**
1	Buell and Niering 1957	Iron Spring	1040			1360	2.5
1	Buell and Niering 1957	Lake Alice	1450			3500	2.5
1	Buell and Niering 1957	Moose River	440			3030	2.5
1	Buell and Niering 1957	Norway Island	690			1010	2.5
1	Buell and Niering 1957	Wilderness Center	1000			2050	2.5
2	Cooper 1913 a, b	Isle Royale					
3	Fassett 1944	Brule River Basin					
4	Hett and Loucks 1976	Thunder Bay--Stand 1				2272	9
4	Hett and Loucks 1976	Thunder Bay--Stand 2				2148	9
4	Hett and Loucks 1976	Thunder Bay--Stand 3		~20		1210	9
5	Jones and Zicker 1955	Rahr Estate	645				
6	Ohmann and Ream 1971b	Boundary Waters--black spruce-jack pine	1788 [1]				
6	Ohmann and Ream 1971b	Boundary Waters--fir-birch	776 [2]				

[1] Density for black spruce and jack pine only.

[2] Density for balsam fir and pine only.

Table 91.—*Basal area of live trees ≥10, ≥50, and ≥70 cm for subboreal spruce-fir old-growth study sites. For other minimum sizes, the basal area is listed under "≥X cm", with the minimum size for tallying trees given as "Min Diam X (cm)".*

			Live Tree Basal Area (BA)				
Map Key	**Source/Date**	**Stand**	**≥10 cm (m^2/ha)**	**≥50 cm (m^2/ha)**	**≥70 cm (m^2/ha)**	**≥ X cm (m^2/ha)**	**Min Diam X (cm)**
1	Buell and Niering 1957	Iron Spring	27.4				
1	Buell and Niering 1957	Lake Alice	31.0				
1	Buell and Niering 1957	Moose River	34.0				
1	Buell and Niering 1957	Norway Island	27.0				
1	Buell and Niering 1957	Wilderness Center	36.0				
2	Cooper 1913 a, b	Isle Royale					
3	Fassett 1944	Brule River Basin					
4	Hett and Loucks 1976	Thunder Bay--Stand 1					
4	Hett and Loucks 1976	Thunder Bay--Stand 2					
4	Hett and Loucks 1976	Thunder Bay--Stand 3					
5	Jones and Zicker 1955	Rahr Estate					
6	Ohmann and Ream 1971b	Boundary Waters--black spruce-jack pine	33.3 [1]				
6	Ohmann and Ream 1971b	Boundary Waters--fir-birch	16.8 [2]				

[1] Basal area for black spruce and jack pine.

[2] Basal area for balsam fir and pine.

Table 92.—*Maximum tree age by species for subboreal spruce-fir old-growth study sites.*

Map Key	Source/Date	Stand	Maximum Tree Age (yr) Black Spruce	Balsam Fir	White Spruce	Jack Pine	Paper Birch
1	Buell and Niering 1957	Iron Spring		60+			
1	Buell and Niering 1957	Lake Alice					
1	Buell and Niering 1957	Moose River		77	125	180	
1	Buell and Niering 1957	Norway Island		60+			
1	Buell and Niering 1957	Wilderness Center		41+	95+		
2	Cooper 1913 a, b	Isle Royale		130-140	240+		190+
3	Fassett 1944	Brule River Basin					
4	Hett and Loucks 1976	Thunder Bay--Stand 1			200+		
4	Hett and Loucks 1976	Thunder Bay--Stand 2					
4	Hett and Loucks 1976	Thunder Bay--Stand 3					
5	Jones and Zicker 1955	Rahr Estate					
6	Ohmann and Ream 1971b	Boundary Waters--black spruce-jack pine					
6	Ohmann and Ream 1971b	Boundary Waters--fir-birch					

Table 93.—*Maximum tree diameter by species, and the percentage of the tree canopy in gaps, for subboreal spruce-fir old-growth study sites.*

Map Key	Source/Date	Stand	Maximum Tree Diameter (cm)					Canopy Gaps (%)
			Black Spruce	Balsam Fir	White Spruce	Jack Pine	Paper Birch	
1	Buell and Niering 1957	Iron Spring						
1	Buell and Niering 1957	Lake Alice						
1	Buell and Niering 1957	Moose River		23	34	46		
1	Buell and Niering 1957	Norway Island		17				
1	Buell and Niering 1957	Wilderness Center						
2	Cooper 1913 a, b	Isle Royale						
3	Fassett 1944	Brule River Basin		36	41			
4	Hett and Loucks 1976	Thunder Bay--Stand 1						
4	Hett and Loucks 1976	Thunder Bay--Stand 2						
4	Hett and Loucks 1976	Thunder Bay--Stand 3						
5	Jones and Zicker 1955	Rahr Estate		9	30			
6	Ohmann and Ream 1971b	Boundary Waters--black spruce-jack pine						
6	Ohmann and Ream 1971b	Boundary Waters--fir-birch						

Table 94.—*Density, basal area, and minimum diameter measured for standing dead trees (snags) in subboreal spruce-fir old-growth study sites.*

			Standing Dead Trees (Snags)		
Map Key	**Source/Date**	**Stand**	**Snag Density (#/ha)**	**Snag Basal Area (m^2/ha)**	**Min Snag Diam (cm)**
1	Buell and Niering 1957	Iron Spring			
1	Buell and Niering 1957	Lake Alice			
1	Buell and Niering 1957	Moose River			
1	Buell and Niering 1957	Norway Island			
1	Buell and Niering 1957	Wilderness Center			
2	Cooper 1913 a, b	Isle Royale			
3	Fassett 1944	Brule River Basin			
4	Hett and Loucks 1976	Thunder Bay--Stand 1			
4	Hett and Loucks 1976	Thunder Bay--Stand 2			
4	Hett and Loucks 1976	Thunder Bay--Stand 3			
5	Jones and Zicker 1955	Rahr Estate			
6	Ohmann and Ream 1971b	Boundary Waters--black spruce-jack pine			
6	Ohmann and Ream 1971b	Boundary Waters--fir-birch			

Table 95.—*Density, volume, and minimum diameter measured for fallen dead trees (logs) for subboreal spruce-fir old-growth study sites.*

			Fallen Dead Trees (Logs)		
Map Key	Source/Date	Stand	Density of Logs (#/ha)	Volume of Logs (m^3/ha)	Min Diam Logs (cm)
1	Buell and Niering 1957	Iron Spring	[1]		
1	Buell and Niering 1957	Lake Alice			
1	Buell and Niering 1957	Moose River			
1	Buell and Niering 1957	Norway Island			
1	Buell and Niering 1957	Wilderness Center			
2	Cooper 1913 a, b	Isle Royale			
3	Fassett 1944	Brule River Basin			
4	Hett and Loucks 1976	Thunder Bay--Stand 1			
4	Hett and Loucks 1976	Thunder Bay--Stand 2			
4	Hett and Loucks 1976	Thunder Bay--Stand 3			
5	Jones and Zicker 1955	Rahr Estate			
6	Ohmann and Ream 1971b	Boundary Waters--black spruce-jack pine			
6	Ohmann and Ream 1971b	Boundary Waters--fir-birch			

[1] Density not given, but mention is made that 10% of downed logs were pine.

Table 96.—*Summary of attributes for old-growth subboreal spruce-fir stands (from Tables 87 through 95).*

Attribute	Range	References (Map Key)
Live Tree Density (#/ha)		
- Trees ≥ 2.5 cm DBH	440 - 1788	1, 5, 6
- Trees ≥ 10 cm DBH	1010 - 3500	1
- Trees ≥ 50 cm DBH	20	4
- Trees ≥ 70 cm DBH	--	--
- Not as specified above		4
Live Tree Basal Area (m^2/ha)		
- Trees ≥ 10 cm DBH	16.8 - 36.0	1, 6
- Trees ≥ 50 cm DBH	--	--
- Trees ≥ 70 cm DBH	--	--
Tree or Stand Age (yr)		
Average Age by Species		
- Not Specified	--	--
Maximum Age by Species		
- Balsam Fir	41+ - 140	1, 2
- White Spruce	95+ - 240+	1, 2, 4
- Jack Pine	180	1
- Paper Birch	190+	2
Maximum Tree Diameter at Breast Height by Species (cm)		
- Balsam Fir	9 - 36	1, 3, 5
- White Spruce	30 - 41	1, 3, 5
- Jack Pine	46	1

(Table 96 continued on next page)

(Table 96 continued)

Attribute	Range	References (Map Key)
Canopy Gaps (%)	--	--
Standing Dead Trees (Snags)		
Snag Density (#/ha)		
- Snags ≥ 10 cm DBH	--	--
- Snags ≥ 10 cm DBH	--	--
Fallen Dead Trees (Logs)		
Density of Logs (#/ha)		
- Logs ≥ 10 cm DBH	--	--
Volume of Logs (m^3/ha)		
- Logs ≥ 10.0 cm DBH	--	--

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APPENDIX A.—COMPLETE LIST OF FOREST TYPE GROUPS IN THE EAST

Forest type groups arranged as upland and lowland groups for the eastern United States, with SAF forest cover types. Forest type groups were created for the purposes of compiling information about old growth and numbers were originally informally assigned as identification numbers. **Those forest type groups treated in this publication are indicated in boldface print.** If the forest type group occurs only minimally within the Eastern and Southern Regions of the USDA Forest Service, the forest type group is identified with "#". Those types noted with "@" primarily occur but within The Nature Conservancy's Eastern, Midwestern, or Southeastern Regions.

Upland forests

1. Northern hardwood forests

- **25 - sugar maple-beech-yellow birch**
- **27 - sugar maple**
- **28 - black cherry-maple**
- **60 - beech-sugar maple**

2. Conifer-northern hardwood forests

a) hemlock-northern hardwood subgroup

- **22 - white pine-hemlock**
- **23 - eastern hemlock**
- **24 - hemlock-yellow birch**

b) white pine-northern hardwood subgroup

- **20 - white pine-northern red oak-red maple**
- **21 - eastern white pine**
- **22 - white pine-hemlock**

c) spruce-northern hardwood subgroup

- **30 - red spruce-yellow birch**
- **31 - red spruce-sugar maple-beech**
- **35 - paper birch-red spruce-balsam fir**

4. Beech-maple-basswood forests

- **26 - sugar maple-basswood**
- **27 - sugar maple**
- **60 - beech-sugar maple**

5. Mixed mesophytic and western mesophytic forests

a) mixed mesophytic subgroup

- 25 - sugar maple-beech-yellow birch
- 27 - sugar maple
- 57 - yellow-poplar
- 58 - yellow-poplar-eastern hemlock
- 59 - yellow-poplar-white oak-northern red oak
- 60 - beech-sugar maple

b) western mesophytic subgroup

- 52 - white oak-black oak-northern red oak
- 57 - yellow-poplar
- 59 - yellow-poplar-white oak-northern red oak

6. Coastal Plain upland mesic hardwood forests

- 53 - white oak
- 82 - loblolly pine-hardwood
- 89 - live oak (in part; mesic salt domes)

7. Southwestern subtropical upland forests (Rio Grande Valley, south Texas)@

None

17. Western lower montane conifer forests@#

- 210 - interior Douglas-fir
- 237 - interior ponderosa pine

18. Western juniper woodlands#

- 66 - Ashe juniper-redberry (Pinchot) juniper
- 220 - Rocky Mountain juniper
- 239 - pinyon-juniper

19. Great Plains riparian hardwood woodlands and savannas@#

40 - post oak-blackjack oak
236 - bur oak

20. Western hardwood gallery forests (mainly Great Plains#

63 - cottonwood
95 - black willow
235 - cottonwood-willow

21. Dry-mesic oak forests

44 - chestnut oak
52 - white oak-black oak-northern red oak
53 - white oak
55 - northern red oak
110 - black oak

22. Dry and xeric oak forests, woodlands, and savannas

a) northern "catastrophic fire" subgroup

14 - northern pin oak
42 - bur oak
110 - black oak

b) widespread subgroup

40 - post oak-blackjack oak
42 - bur oak
43 - bear oak (where larger *Quercus* species co-occur and dominate the overstory)
44 - chestnut oak
110 - black oak

c) southern subgroup
67 - Mohrs ("shin") oak
72 - southern scrub oak
89 - live oak

23. Mesic and wet-mesic northern oak forests, woodlands, and savannas

42 - bur oak
52 - white oak-black oak-northern red oak
53 - white oak
55 - northern red oak

24. Xeric pine and pine-oak forests and woodlands

43 - bear oak (where overstory *Pinus* species co-occur and dominate the overstory)
45 - pitch pine
51 - white pine-chestnut oak
75 - shortleaf pine
76 - shortleaf pine-oak
78 - Virginia pine-oak
79 - Virginia pine

25. Dry and dry-mesic oak-pine forests

51 - white pine-chestnut oak
75 - shortleaf pine
76 - shortleaf pine-oak
78 - Virginia pine-oak
79 - Virginia pine
80 - loblolly pine-shortleaf pine
81 - loblolly pine
82 - loblolly pine-hardwood

26. Upland longleaf and south Florida slash pine forests, woodlands, and savannas

70 - longleaf pine
71 - longleaf pine-scrub oak
83 - longleaf pine-slash pine
111 - south Florida slash pine

27. Seasonally wet oak-hardwood woodlands ('oak flatwoods;' low intensity, widespread fire; seasonally flooded; hard pan)

40 - post oak-blackjack oak ("on heavier, clayey soils the type tends towards the post oak variant")
53 - white oak ("occasionally it occurs on poorly drained bottomland soils with a high clay content")
65 - pin oak-sweetgum
88 - willow oak-water oak-diamondleaf (laurel) oak (the type may also occur on terrace flats and poorly drained flatwoods sites and is often referred to as oak glades' or 'pin oak flats')

30. Subboreal spruce and spruce-fir forests

5 - balsam fir
12 - black spruce (subtypes a, b, c)
107 - white spruce

31. Montane and allied spruce and spruce-fir forests

- **5 - balsam fir**
- **30 - red spruce-yellow birch**
- **32 - red spruce**
- **33 - red spruce-balsam fir**
- **34 - red spruce-Fraser fir**
- **35 - paper birch-red spruce-balsam fir**

32. Aspen-birch forests and woodlands

a) successional aspen-birch forests and woodlands (interior Eastern Deciduous Forest)

- 16 - aspen
- 18 - paper birch
- 19 - gray birch-red maple

b) aspen parkland forests, woodlands, and scrub (western border of Eastern Deciduous Forest)#

- 16 - aspen

34. Sand pine forests and woodlands

- 69 - sand pine

35. Northern pine forests

a) short-lived pines

- **1 - jack pine**
- 45 - pitch pine

b) long-lived pines

- **15 - red pine**
- **21 - eastern white pine**

37. Rocky, thin-soiled, excessively-drained cedar woodlands (pavement barrens, glades, rocky outcrops, granitic flatrock borders; widely spaced, stunted trees)

- 37 - northern white-cedar (limestone cliff faces)
- 46 - eastern redcedar

38. Barrier island (maritime) mixed forests and woodlands

- 73 - southern redcedar
- 74 - cabbage palmetto
- 89 - live oak

Lowland forests

8. Northern conifer wetland/bog forests

a) white-cedar subgroup

- 37 - northern white-cedar

b) black spruce-tamarack subgroup

- 12 - black spruce (subtypes d, e, f)
- 13 - black spruce-tamarack
- 38 - tamarack

10. Hardwood (elm-ash-maple) wetland forests

- **39 - black ash-American elm-red maple**
- **65 - pin oak-sweetgum (in part)**
- **108 - red maple**

12. Hardwood freshwater tidal swamps

- 108 - red maple

13. River floodplain hardwood forests

- 65 - pin oak-sweetgum
- 82 - loblolly pine-hardwood
- 87 - sweetgum-yellow poplar
- 88 - willow oak-water oak-diamondleaf (laurel) oak
- 91 - swamp chestnut oak-cherrybark oak
- 92 - sweetgum-willow oak
- 93 - sugarberry-American elm-green ash
- 94 - sycamore-sweetgum-American elm
- 96 - overcup oak-water hickory
- 108 - red maple

14. Cypress-tupelo swamp forests

- 100 - pondcypress
- 101 - baldcypress
- 102 - baldcypress-tupelo
- 103 - water tupelo-swamp tupelo

15. Tropical and subtropical wetland forests and woodlands (south Florida)

- 105 - tropical hardwoods

16. Mangrove swamps (south Texas, south Florida)

    106 - mangrove

28. Eastern riverfront forests

    61 - river birch-sycamore
    62 - silver maple-American elm
    63 - cottonwood
    89 - live oak
    94 - sycamore-sweetgum-American elm
    95 - black willow

29. Southern wet pine forests, woodlands, and savannas

    70 - longleaf pine
    83 - longleaf pine-slash pine
    84 - slash pine
    85 - slash pine-hardwood
    98 - pond pine

40. Atlantic white-cedar forests

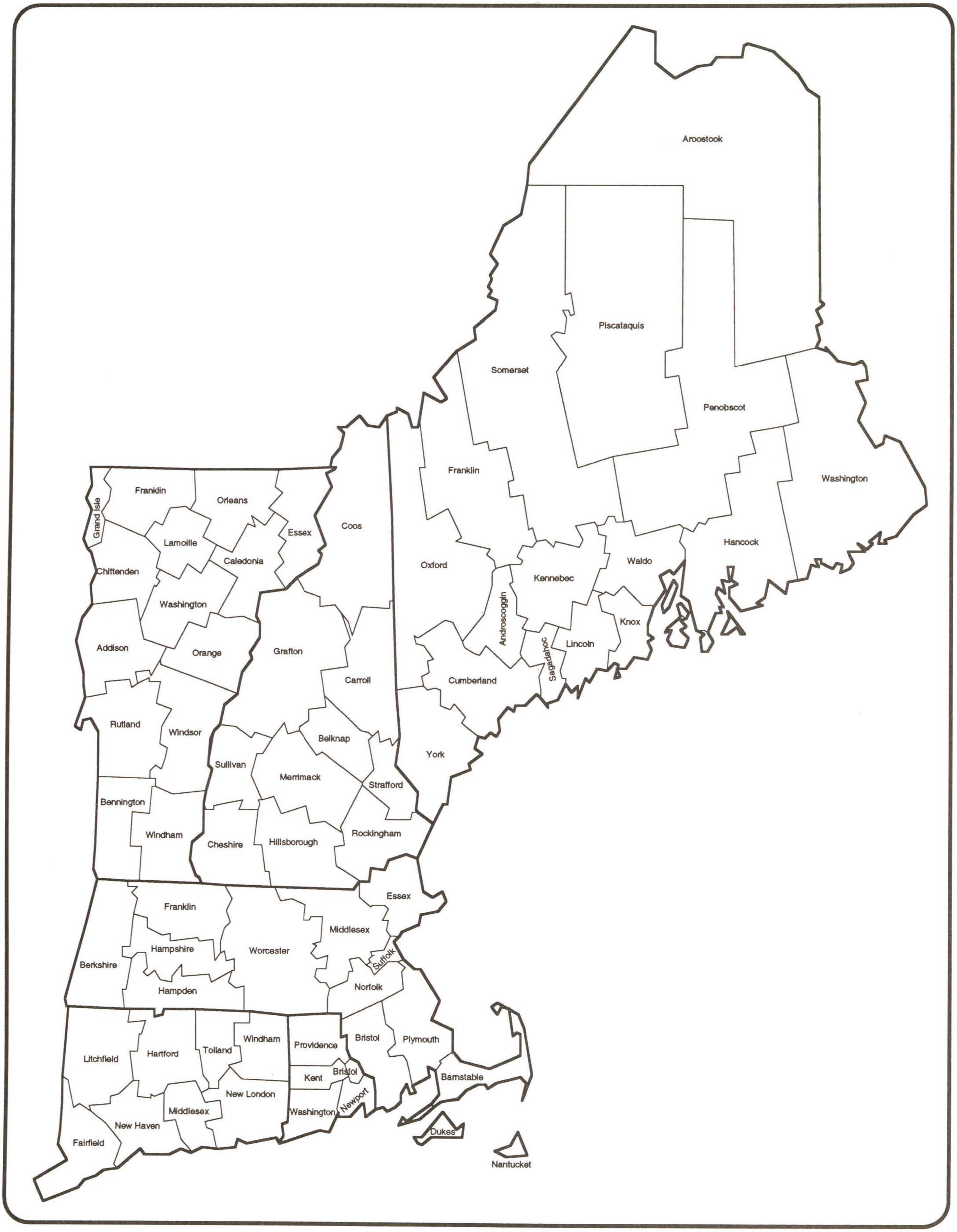
    97 - Atlantic white-cedar

41. Bay (loblolly-, sweet-, and redbay) forests

    84 - slash pine
    85 - slash pine-hardwood
    104 - sweetbay-swamp tupelo-redbay

APPENDIX B.—STATE MAPS WITH COUNTY NAMES

New England	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont (page 464)
Mid-Atlantic/South	Delaware, Kentucky, Maryland, New Jersey, North Carolina, Tennessee, Virginia, West Virginia (page 465)
East	New York, Ohio, Pennsylvania (page 466)
Upper Midwest	Michigan, Minnesota, Wisconsin (page 467)
Central	Illinois, Indiana, Iowa, Missouri (page 468)
South-Central	Arkansas, Oklahoma (page 469)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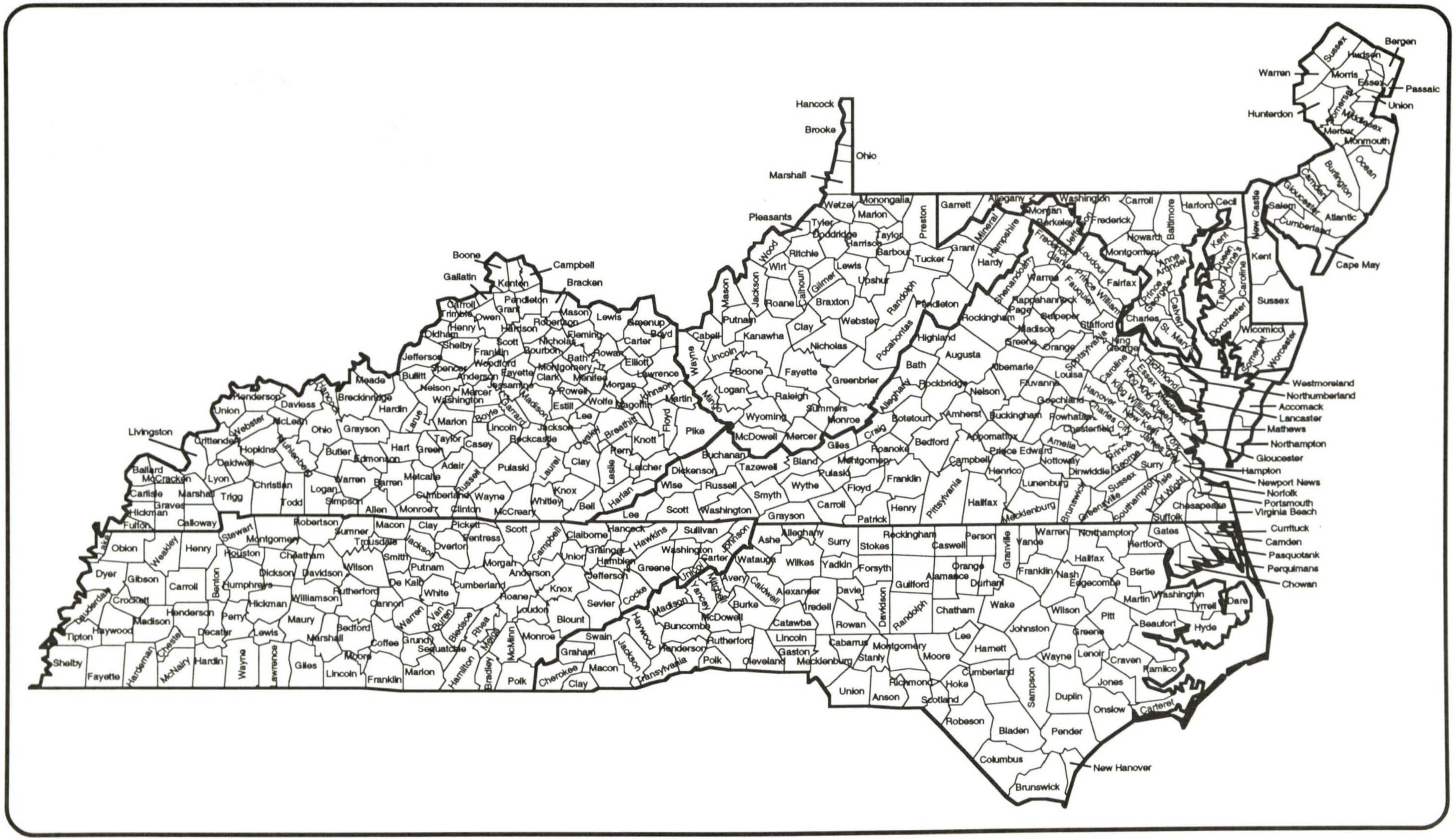
Cumberland
York
Coos
Grafton
Carroll
Belknap
Sullivan
Merrimack
Strafford
Cheshire
Hillsborough
Rockingham
Franklin
Orleans
Grand Isle
Essex
Lamoille
Caledonia
Chittenden
Washington
Addison
Orange
Rutland
Windsor
Bennington
Windham
Essex
Franklin
Middlesex
Hampshire
Worcester
Berkshire
Suffolk
Hampden
Norfolk
Bristol
Plymouth
Barnstable
Dukes
Nantucket
Providence
Kent
Bristol
Washington
Newport
Litchfield
Hartford
Tolland
Windham
New London
Middlesex
New Haven
Fairfield

New England—Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont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Camden
Gloucester
Salem
Atlantic
Cumberland
Cape May
Hancock
Brooke
Ohio
Marshall
Pleasants
Wetzel
Monongalia
Marion
Tyler
Doddridge
Taylor
Harrison
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Ritchie
Wood
Wirt
Barbour
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Lewis
Upshur
Jackson
Mason
Roane
Calhoun
Gilmer
Braxton
Randolph
Webster
Putnam
Kanawha
Clay
Cabell
Lincoln
Wayne
Nicholas
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Boone
Fayette
Greenbrier
Logan
Raleigh
Mingo
Wyoming
Summers
Monroe
McDowell
Mercer
Garrett
Allegany
Mineral
Hampshire
Grant
Hardy
Pendleton
Morgan
Berkeley
Jefferson
Washington
Frederick
Carroll
Baltimore
Harford
Cecil
Howard
Montgomery
Anne Arundel
Prince Georges
Calvert
Charles
St. Mary's
Kent
Queen Annes
Talbot
Caroline
Dorchester
Wicomico
Somerset
Worcester
New Castle
Kent
Sussex
Frederick
Clarke
Loudoun
Shenandoah
Warren
Fauquier
Prince William
Fairfax
Rockingham
Page
Rappahannock
Culpeper
Stafford
Madison
Greene
Orange
Spotsylvania
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Highland
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Albemarle
Louisa
Caroline
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Bath
Rockbridge
Nelson
Fluvanna
Goochland
Hanover
King William
Essex
Richmond
Northumberland
Lancaster
Middlesex
Alleghany
Botetourt
Amherst
Buckingham
Powhatan
Charles City
New Kent
King And Queen
Mathews
Gloucester
Accomack
Northampton
Craig
Roanoke
Bedford
Appomattox
Chesterfield
Amelia
Prince Edward
James City
York
Giles
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Bland
Pulaski
Franklin
Campbell
Henrico
Nottoway
Dinwiddie
Prince George
Surry
Buchanan
Tazewell
Dickenson
Wise
Russell
Smyth
Wythe
Floyd
Lunenburg
Sussex
Isle of Wight
Southampton
Hampton
Newport News
Norfolk
Portsmouth
Virginia Beach
Chesapeake
Suffolk
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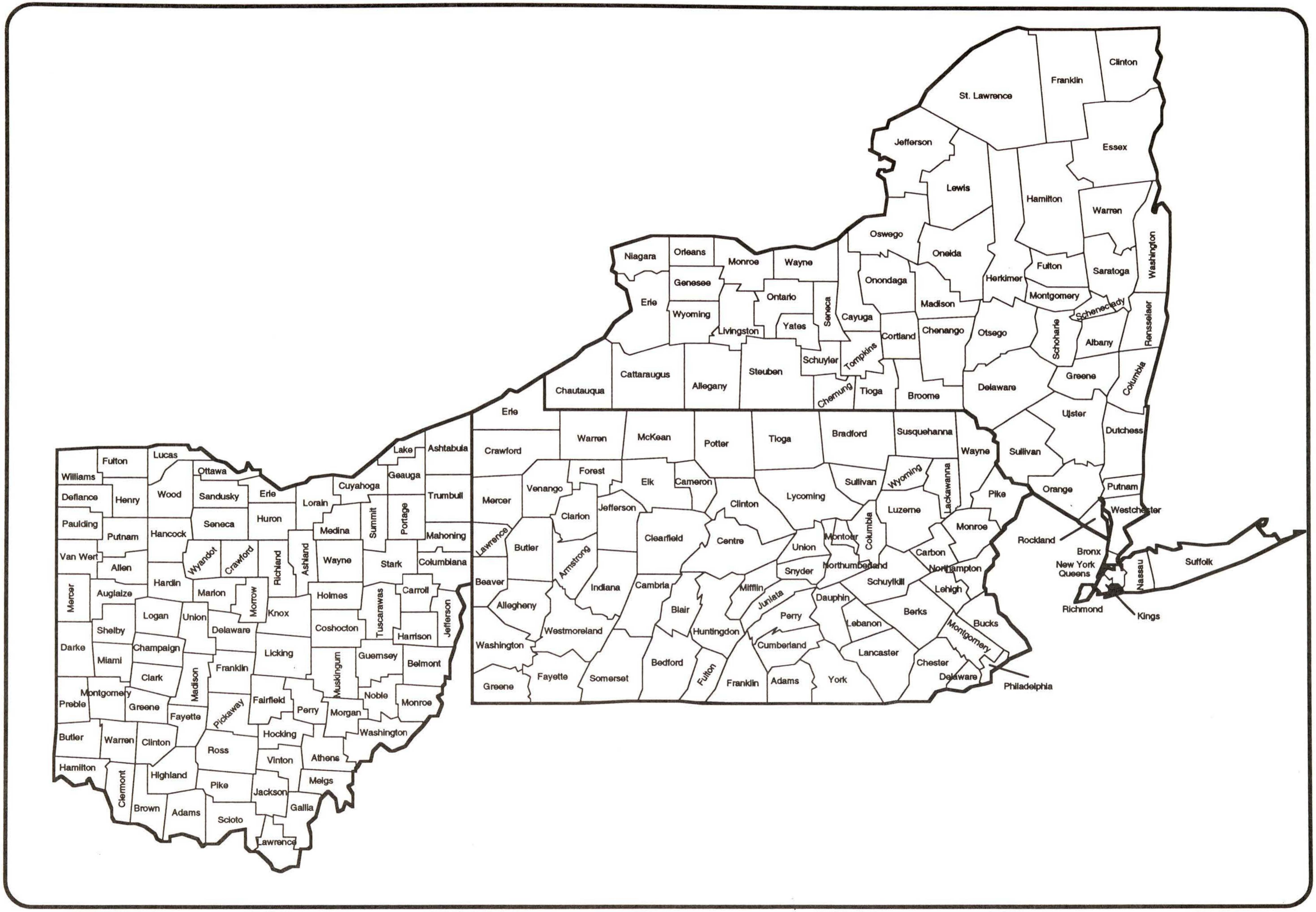
Columbus
Brunswick
New Hanover

Mid-Atlantic/South—Delaware, Kentucky, Maryland, New Jersey, North Carolina, Tennessee, Virginia, West Virginia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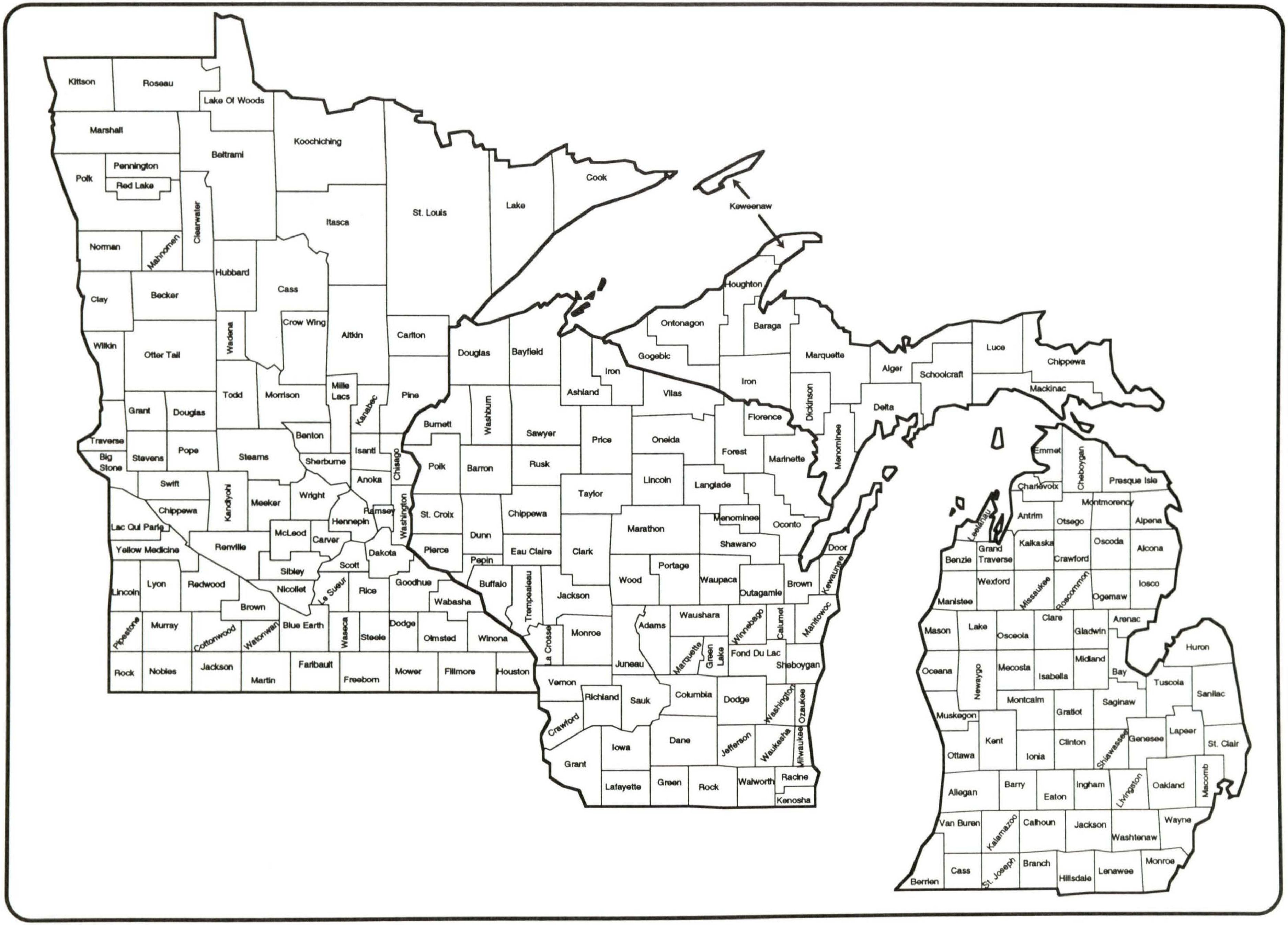
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Hubbard
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Cass
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Aitkin
Carlton
Wilkin
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Douglas
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Benton
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Ramsey
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Cottonwood
Watonwan
Blue Earth
Waseca
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Dodge
Olmsted
Winona
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Nobles
Jackson
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Freeborn
Mower
Fillmore
Houston
Douglas
Bayfield
Ashland
Iron
Vilas
Burnett
Washburn
Sawyer
Price
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Forest
Florence
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Polk
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Rusk
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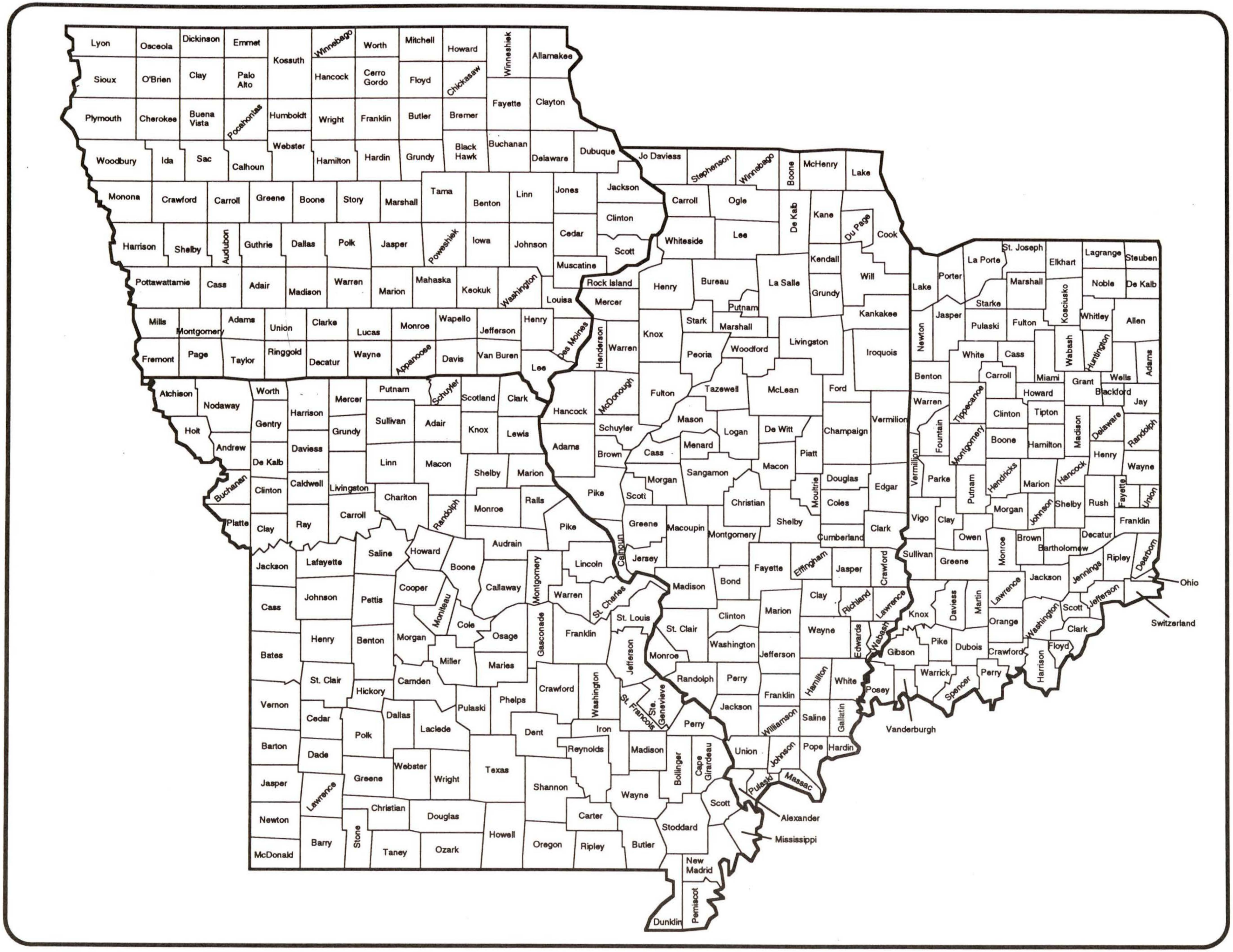
Upper Midwest—Michigan, Minnesota, Wisconsin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Appanoose
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Stephenson
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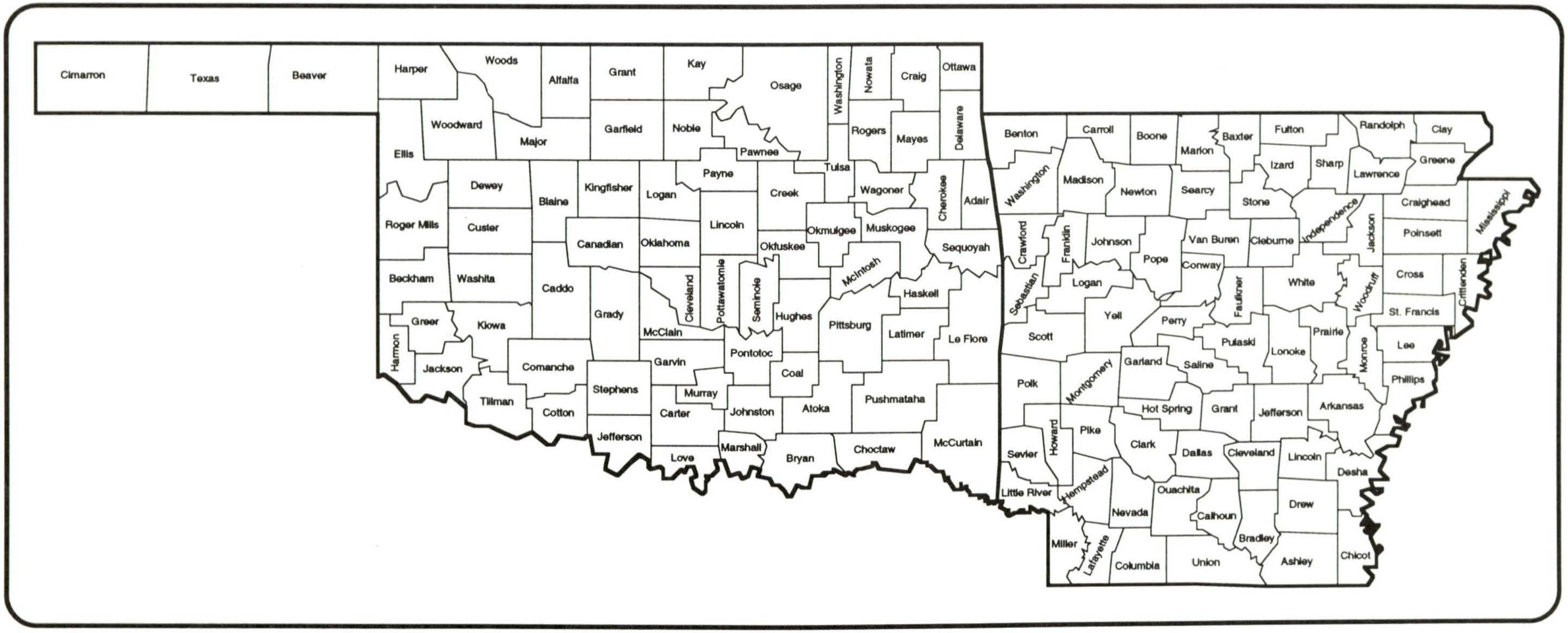
Central—Illinois, Indiana, Iowa, Missouri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Jackson
Comanche
Garvin
Pontotoc
Coal
Stephens
Murray
Tillman
Cotton
Carter
Johnston
Atoka
Pushmataha
Jefferson
Marshall
Love
Bryan
Choctaw
McCurtain
Benton
Carroll
Boone
Marion
Baxter
Fulton
Randolph
Clay
Izard
Sharp
Greene
Lawrence
Washington
Madison
Newton
Searcy
Stone
Craighead
Mississippi
Independence
Crawford
Franklin
Johnson
Van Buren
Cleburne
Jackson
Poinsett
Pope
Conway
Sebastian
Logan
White
Cross
Crittenden
Woodruff
Faulkner
Yell
Perry
St. Francis
Scott
Prairie
Pulaski
Lonoke
Lee
Monroe
Garland
Saline
Montgomery
Polk
Phillips
Hot Spring
Grant
Jefferson
Arkansas
Pike
Howard
Clark
Sevier
Dallas
Cleveland
Lincoln
Desha
Hempstead
Little River
Ouachita
Nevada
Calhoun
Drew
Bradley
Miller
Lafayette
Columbia
Union
Ashley
Chicot

South Central—Arkansas, Oklahoma

APPENDIX C.—NON-CITED REFERENCES PERTAINING TO FOREST TYPE GROUPS

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APPENDIX D. ADDENDUM: RECENT REFERENCES

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